APRIL 1951

Journal

VOL. 43 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

In this issue

HEADIN' FOR MIAMI

AND THE A.W.W.A. CONVENTION

APRIL 29
TO MAY 4

A warm welcome awaits you at the booth where R. D. Wood products will be on display. We are looking forward to showing you the famous Mathews replaceable barrel—a feature that is incorporated in the hydrants of the modern fire-fighting system of the city of Miami.

MATHEWS HYDRANTS

Made by R. D. Wood Company
Public Ledger Building, Independence Square
Philadelphia 5, Pa.
Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

AMERICAN WATER WORKS ASSOCIATION
INCORPORATED

521 Fifth Avenue, New York 17, N.Y.
(***Telephone: MUrray Hill 2-4515***)

Board of Directors

Administrative Staff

Journal A.W.W.A. is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N. Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918.

Made in United States of America

DIVISION AND SECTION OFFICERS

Officers of the Divisions

Water Purification Division—Chairman, H. E. LORDLEY; Vice-Chairman, H. O. HARTUNG; Secretary-Treasurer, R. L. DERBY; Directors, M. E. FLENTJE, W. W. AULTMAN.

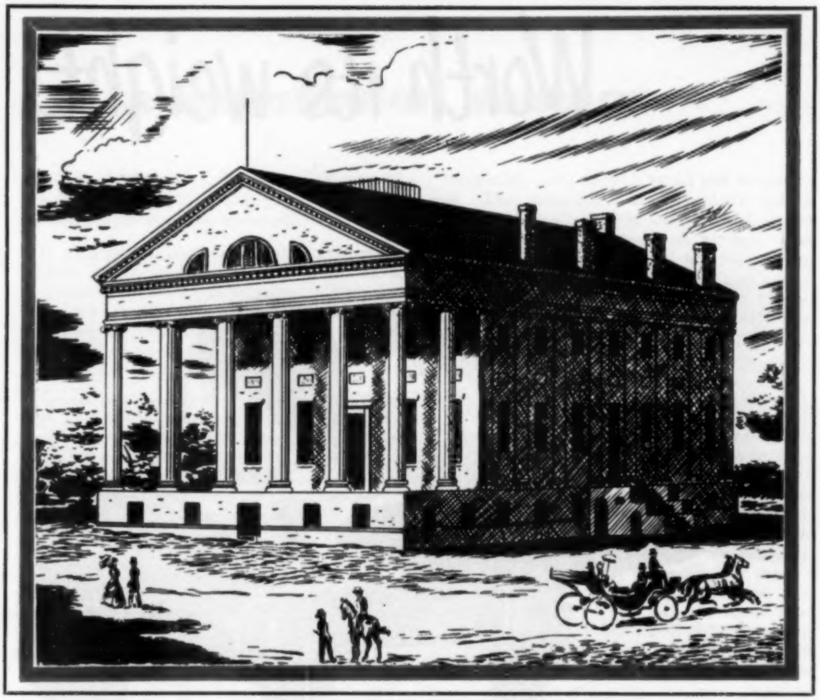
Water Resources Division—Chairman, H. E. HUDSON, JR.; Vice-Chairman, RICHARD HAZEN; Secretary-Treasurer, G. E. FERGUSON; Directors, DALE MAFFITT, FRED MERRYFIELD

Water Works Management Division—Chairman, L. J. HOFFMAN; Vice-Chairman, PAUL WEIR; Secretary-Treasurer, J. L. HAWKINS; Directors, M. B. CUNNINGHAM, J. W. MYERS.

Officers of the Sections

*Section**	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*	*Past-Chairman*
Alabama-Miss.	T. H. Allen	E. M. Stickney	C. W. White	G. H. Godwin
Arizona	G. W. Marx	S. P. Henderson	Mrs. H. Rotthaus	A. A. Frederickson
California	G. E. Arnold	J. D. DeCosta	W W. Aultman	E. A. Reinke
Canadian	R. Harrison		A. E. Berry	N. MacNicol
Chesapeake	David Auld	E. B. Showell	C. J. Lauter	C. Gardner
Cuban	L. Radelat	G. Bequer H.	L. H. Daniel	M. J. Puente
Florida	S. W. Wells	R. F. Brennan	M. R. Boyce	S. K. Keller
Illinois	W. R. Gelston	E. E. Alt	J. L. Hart	J. C. Moomau
Indiana	C. H. Bechert	O. A. Newquist	G. G. Fassnacht	J. Gordon
Iowa	M. E. Driftmier	M. K. Tenny	H. V. Pedersen	G. Nelson
Kansas	A. W. Rumsey	R. H. Hess	H. W. Badley	A. B. Mawdsley
Kentucky-Tenn.	J. W. McCoy	C. H. Bagwell	R. P. Farrell	R. W. Williamson
Michigan	G. Hazey	L. E. Ayres	T. L. Vander Velde	J. E. Cooper
Minnesota	R. M. Jenson	Rhea Rees	L. N. Thompson	A. F. Mellen
Missouri	C. E. Schanze	W. E. Ralls	W. A. Kramer	R. E. Piner
Montana	H. McCann	M. E. Henderson	A. W. Clarkson	M. F. Dixon
Nebraska	C. W. Burdick	L. D. Wright	E. B. Meier	V. Livingston
New England	D. C. Calderwood	W. J. Shea	G. G. Bogren	W. A. Gentner
New Jersey	A. Shinn	E. A. Bell	C. B. Tygert	R. E. Bonyun
New York	A. T. Luce	R. W. Austin	R. K. Blanchard	L. B. Smith
North Carolina	W. W. Adkins	H. F. Davis	E. C. Hubbard	E. R. Tull
Ohio	A. S. Hibbs	L. J. Hoffman	F. P. Fischer	A. A. Ulrich
Pacific Northwest	E. James	W. G. Wilmot	O. P. Newman	B. C. Gosney
Pennsylvania	T. H. Kain	J. D. Johnson	L. S. Morgan	E. C. Goehring
Rocky Mountain	C. G. Caldwell	R. L. Sherard	G. J. Turre	B. V. Howe
Southeastern	Sherman Russell	T. M. Rogers	T. A. Kolb	J. F. Pearson
Southwest	K. E. Hoefle	Henry Wilkins	L. A. Jackson	J. R. Pierce
Virginia	R. D. Wright	B. L. Strother	W. H. Shewbridge	E. C. Meredith
West Virginia	W. S. Staub	M. B. Stewart	H. K. Gidley	M. K. Jones
Wisconsin	F. K. Quimby	E. F. Tanghe	L. A. Smith	T. M. McGuire

* For Section's representative on the A.W.W.A. Board of Directors, see list on page ii.



Richmond's State Capitol, completed in 1792, as it looked 100 years ago

COMING MEETINGS

April 5–6—New York Section at Hotel Ten Eyck, Albany. Secretary: R. K. Blanchard, Vice-Pres., Neptune Meter Co., 50 W. 50 St., New York 20.

11–13—Kansas Section at Lamer Hotel, Hays. Secretary: H. W. Badley, Neptune Meter Co., 640 Highland St., Salina.

19–20—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Dept. of Civ. Eng., University of Nebraska, Lincoln.

20–21—Montana Section at Placer Hotel, Helena. Secretary: A. W. Clarkson, Asst. Director, Div. of San. Eng., State Board of Health, 1036 Eighth Ave., Helena.

A.W.W.A. 1951 ANNUAL CONFERENCE

Miami, Florida

April 29—May 4

71st Annual Conference

Apr. 29–May 4—Southeastern Section will hold a business meeting during the Miami Conference.

May 17–19—Pacific Northwest Section at Vancouver Hotel, Vancouver, B.C. Secretary: O. P. Newman, Secy., Boise Water Corp., Boise, Idaho.

21–23—Canadian Section at Royal Alexandra Hotel, Winnipeg, Man. Secretary: A. E. Berry, Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

June 29—New Jersey Section Summer Meeting (inspection trip and luncheon), Trenton, N.J. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

JUST OFF THE PRESS

Bulletin #9041... 32 pages of data, photos and drawings in color describing the Dorrco Hydro-Treator... the high-rate water treatment unit that gives these results

PLANT	JUNCTION CITY, KANSAS	[illegible], OHIO	APPLETON, WISCONSIN	A CANADIAN PAPER CO.	T.V.A., SHEFFIELD, ALABAMA
OPERATION	SOFTENING	SOFTENING	SOFT. COLOR & TURB. REM.	COLOR REM.	ALGAE & COLOR REM.
NO. & SIZE OF UNITS	2–35' DIA.	1–31' DIA.	1–45' DIA.	2–80' DIA.	1–50' DIA.
CAP. PER UNIT, M.G.D.	1.5	2.0	2.1	10.0	3.0
GAL/SQ. FT./MIN.	1.00	.98	1.35	1.94	1.07
AVG. TURB. EFF. PPM	LESS THAN 1.2	3.0	2.4 TO 4.7	2 TO 5	4 TO 2
SLUDGE–% SOLIDS	[illegible] TO 4.5	24.7 TO 30.2	14.7	–	

Write for your free copy today . . . or, better still, come see our exhibit in booths 118 and 119 at the A.W.W.A. Convention in Miami, April 29 to May 4 and pick up your copy there.

DORRCO

DORR

WORLD - WIDE RESEARCH · ENGINEERING · EQUIPMENT

THE DORR COMPANY · ENGINEERS · STAMFORD, CONN

Associated Companies and Representatives in the principal cities of the world

Journal

AMERICAN WATER WORKS ASSOCIATION

April 1951

Vol. 43 • No. 4

Contents

Departments

Indexed annually in December; and regularly by *Industrial Arts Index and Engineering Index*.

Microfilm edition (for Journal subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

Harry E. Jordan, Secretary—521 Fifth Avenue, New York 17, N.Y.

$7.00 of members' dues are applied as a subscription to the Journal; additional single copies to members—50 cents; single copies to non-members—75 cents.

Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 43 • APRIL 1951 • NO. 4

Economics of Water Softening

By Louis R. Howson

A paper presented on February 7, 1951, at the Indiana Section Meeting, Indianapolis, Ind., by Louis R. Howson, Cons. Engr., Alvord, Burdick & Howson, Chicago, Ill.

BECAUSE standards of quality for public water supplies have become increasingly exacting, the water which reaches the consumer in the U.S. today is almost invariably safe, generally clear and sparkling, and usually palatable. And as the quality standards have improved, the public has become more and more conscious of the remaining deficiency of so many water supplies—hardness.

People like soft water. This fact has been capitalized on by a number of forward-looking companies that have organized to dispense soft water service of one type or another. In the most common type the supplier installs a zeolite softener on the consumer's main hot water line, servicing the unit as often as necessary to maintain a supply of soft water. The usual charge for this class of service is from $2.50 to $3.50 a month, or approximately twice as much as the consumer pays for his entire water use. Even at this high cost, however, thousands of public water supply users are availing themselves of softener service in communities where the public supply is hard.

When those who can afford it will buy soft water service at a cost equivalent to a 300 per cent increase in their water rates, no economic justification would seem to be required for softening the entire supply at a cost which ranges from 4¢ per 1,000 gal. to a possible maximum, for very small plants, of 10¢ per 1,000 gal.

That water utilities are beginning to recognize their obligation to furnish more than just safe water is evident: in the decade from 1935 to 1945 the number of people in the United States receiving softened water doubled. During that decade more new softening plans were built, and more people were given the advantage of soft water, than in the 30 years previous.

For many years the late H. M. Olson maintained a census of water

softening plants (Fig. 1). As of January 1945 Olson recorded (1) 665 softening plants serving approximately 12,000,000 people with softened water. Complete data are not available on the growth since 1945, but in the author's office alone during that period, softening plants with an aggregate capacity of 186 mgd., or nearly 10 per cent of the 1945 capacity, have been designed. It is probable, therefore, that the number of people in the United States now

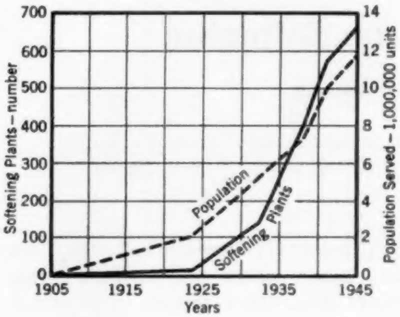


Fig. 1. Increase in Water Softening Plants

Data were gathered by the late H. M. Olson and are not available from 1945 to date; however, the author estimates that approximately 15 million people in the U.S. now receive softened water.

receiving softened water is approaching 15,000,000.

Savings Effected

In 1932 Hudson and Buswell conducted a study of soap waste caused by hardness in public water supplies, using as a basis of estimate the cost of soap prevailing at the time (2). These figures, brought up-to-date by T. E. Larson (3) in 1948, are shown graphically in Fig. 2. It may be seen that the average annual expenditure for soap, in a city with a water supply of 285 ppm. hardness, would be approximately \$10.70 per capita, whereas the annual per capita expenditure for soap with the hardness lowered to 85 ppm. would be \$8.20. The difference of \$2.50 per capita applied to an average family of four would amount to \$10.00 a year for each family. It must be borne in mind moreover that soap savings are only one of a number of important benefits effected by water softening.

The author recently visited a city whose water supply contained approximately 300 ppm. of hardness and 1 ppm. of iron. Inquiry revealed that approximately 1,000 of the 3,100 water customers had some type of soft water service. Of these it was estimated that less than one-fourth owned their own softeners and that the remaining three-fourths took soft water service from one of the companies operating in the city. It was also found that the cost of softening the water ranged from \$2.50 per month for one service call to \$3.50 per month for two, with an overall average of approximately \$3.00. Those customers who purchased a soft water service received soft water on hot water lines only; in the aggregate, they were paying approximately \$36,000 a year for it, an amount greater than the cost of softening the entire water supply of the city. A municipal softening plant could have furnished both hot and cold softened water to all at a cost less than one-third that paid for soft, hot water only. Softening the water would, at the same time, have solved the iron removal problem.

Installation Costs

Construction costs of a number of lime-soda softening plants have been analyzed in terms of current prices based on the *Engineering News-Record* Construction Cost Index,

which, using a base of 1913 = 100, currently stands at approximately 530. The results of this analysis are shown in Fig. 3. The data for the diagram —all recent—are based upon actual construction costs and estimates and they indicate that large softening plants, in the 80-mgd. range, can be built for approximately $55,000 per mgd. of capacity at present. This estimate contemplates the softening of well water using filtration rates of 3 gpm. per sq.ft.

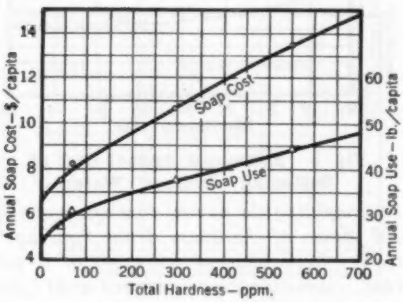


Fig. 2. Soap Waste Caused by Hardness

The average annual expenditure for soap with a water of 285 ppm. hardness is approximately $10.70 per capita, whereas the per capita expenditure for soap with hardness lowered to 85 ppm. would be $8.20, a difference of $2.50 per capita.

The cost per unit of capacity increases for smaller plants. Two 48-mgd. plants, recently contracted for, cost approximately $60,000 per mgd. Plants in the 12–15 mgd. range will cost approximately $90,000 per mgd. capacity; a 2 mgd. plant would cost about $250,000.

The 1951 softening plant construction costs, shown in Fig. 3, are based upon lime-soda plants using either conventional, mechanically cleaned settling basins with 45 minutes slow mixing and 4 hours settling, or suspended solids contact clarifiers with 2-hour detention periods.

Annual Cost

Determination of the type of softening plant, its construction and annual operating cost must be based on a consideration of the specific qualities of the water to be softened. Each plant should be tailored to its individual needs. It is practicable, however, to indicate in a very general way the types of water for which certain processes may be economically adapted. The applicability and comparative cost of chemicals per mil.gal softened, based upon a water of 515 ppm. hardness, of which 430 ppm. are to be removed, are indicated in Fig. 4. The total hardness is shown to vary from 100 per cent carbonate hardness to 100 per cent permanent hardness, with a sulfate content of 100 per cent calcium sulfate in one water, and 50 per cent calcium, and 50 per cent magnesium sulfate in the other.

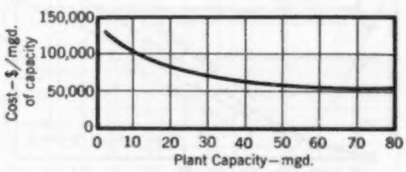


Fig. 3. Construction Costs of Softening Plants—1951

Construction costs of a number of lime-softening plants, of the conventional or solids contact clarifier type, have been analyzed in terms of current prices, based on the E.N.-R. Construction Cost Index 530 (1913 = 100).

The cost of salt used in regenerating ion exchange filters, based upon the use of 0.35 lb. of salt per 1,000 grains of

hardness removed, is also shown in Fig. 4. The chemical costs used in preparing the comparison were: salt, $15 per ton; lime, $15 per ton; and soda-ash, $32 per ton.

The graph shows that, with 515 ppm. hardness, the lime-soda process offers a lower chemical cost than ion exchange, unless from 75 to 90 per cent of the hardness is of the permanent type. The cost of chemicals varies from slightly over $5.00 per mil.gal per 100 ppm. of hardness removed to

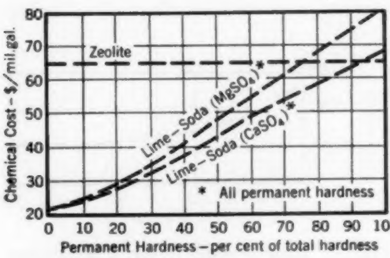


Fig. 4. Cost of Softening Chemicals

The applicability and comparative cost of chemicals used to remove 25 grains of hardness from 30-grain hardness water is indicated above. The lime-soda process offers a lower chemical cost than ion exchange unless from 75 to 90 per cent of the hardness is of the permanent type.

nearly $20. The chemical cost of removing hardness by the lime-soda process from water in which 60 per cent of the hardness is permanent and, of that proportion 25 per cent is magnesium sulfate, would be approximately $12 per mil.gal. That sum has been used as representative of the chemical cost of softening "average" 285 ppm. hardness water.

Annual costs of softening include: [1] fixed charge on investment, [2] chemicals and [3] labor.

The annual cost of operating plants removing 200 ppm. of hardness from "average" water is shown in Fig. 5. In computing this cost, fixed charges were set at 6 per cent, a relatively high figure for municipal plants but lower than the amount required for a fair return and depreciation allowance for privately owned plants; chemicals were estimated at $12 per mil.gal. per 100 ppm. of hardness removed from raw water of 285 ppm. hardness reduced to

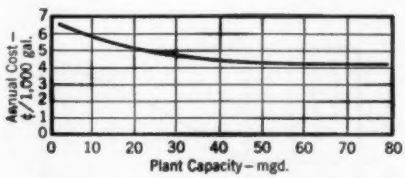


Fig. 5. Estimated Annual Cost of Softening "Average" Water

In computing the annual cost of removing 200 ppm. of hardness from "average" water, fixed charges were set at 6 per cent; chemicals were estimated at $12 per mil.gal per 100 ppm. of hardness removed; labor costs were estimated from operating records. On this basis, the annual cost of softening was found to be approximately 6.2¢ per 1,000 gal. for a 6-mgd. plant, decreasing to approximately 4.1¢ for an 80-mgd. plant.

85 ppm.; the cost of labor was estimated from records of plants in operation. The computation is based on the further assumption that the softening plant will operate at a 60 per cent load factor, that is, that plant capacity equivalent to 1⅔ times the average day's output will be provided.

Under these conditions, the annual cost of softening was found to be approximately 6.2¢ per 1,000 gal. for a 6-mgd. plant, decreasing to approximately 4.1¢ for an 80-mgd. plant.

The unit costs listed above are based upon the total cost of building a filtration plant to provide for softening as well. When a filtration plant is under consideration, it is usually practicable to take account of softening in the design by providing additional chemical storage and handling and feeding equipment, and by installing mechanical equipment in the settling basins at a cost approximately 15 per cent above that required for filtration alone. If fixed charges on only the additional cost were allocated to softening, the above figures would be reduced by 30 to 40 per cent, and the cost of removing 200 ppm. of hardness would then vary from 4.6¢ per 1,000 gal. for a 6-mgd. plant to 2.9¢ for an 80-mgd. plant.

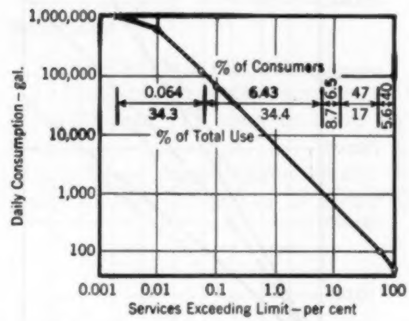


Fig. 6. Customer Classification by Daily Use

A classification system showing the number of customers falling within specific daily use limits indicates that only 10 per cent use more than 800 gpd.

Cost to the Consumer

It is not generally appreciated that the cost of softening water to the average consumer is so small. In the average American water works system, 50 per cent of the water used is consumed by less than 5 per cent, and frequently by less than 1 per cent, of the total number of customers. As an average therefore, 50 per cent of all customers use less than approximately 3,000 gal. per month each, permitting a low cost for most.

A classification of customers by the average daily use of each is presented in Fig. 6, which indicates that only 10 per cent of customers use more than 800 gpd. per service, or 24,000 gal. monthly.

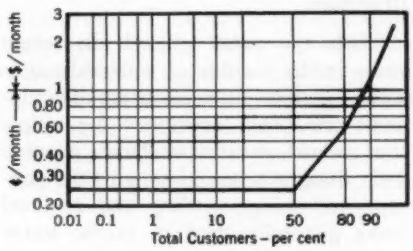


Fig. 7. Rate Increase Effect on Customers

The extent to which customers would be affected by water rate increases sufficient to cover the cost of removing 200 ppm. of hardness is shown to be slight. The additional monthly cost to 50 per cent of all customers would be only 25¢.

By combining the data of Fig. 6, giving a classification of customers by use, and Fig. 5, giving the estimated cost per mil.gal. of removing 200 ppm. of hardness, Fig. 7 was prepared. It shows that 50 per cent of the customers who use 3,000 gal. per month or less at a minimum monthly charge of approximately $1.50 would be billed an additional 25¢ for softening.

For at least 80 per cent of the customers, the cost of water softening would be less than 60¢ per month or

2¢ per family daily. In almost any city water supply from which 200 ppm. of hardness was removed, 90 per cent of the customers would have their bills increased less than 4¢ each, daily, 1¢ per capita, to cover the cost of softening in the utility plant.

The remainder of the cost of softening would be borne by a small percentage of large users—a few large residential users and commercial and industrial consumers—who would have their bills increased approximately 5¢ per 1,000 gal. or 1¼¢ per ton.

Clarifiers

With the rapid growth in recent years in the number of softened public water supplies, manufacturers of equipment previously developed for industrial water treatment have adapted their designs to compete with the conventional sludge settling and removal tanks generally used in public water supply softening practice.

There has been much discussion on types of what have come to be known as "suspended solids contact clarifiers," of which there are now at least eight on the mraket. For the past two or three years, an A.W.W.A. committee, under the chairmanship of H. O. Hartung,* has been studying capacity and loadings for these devices.

It is the author's belief that the choice between a conventional and a suspended solids contact clarifier is, in the last analysis, determined by an evaluation of working efficiencies, flexibility and results in terms of cost.

The various manufacturers have adopted certain designs, on the basis of which equipment is offered. Competition is keen and has resulted in the adoption of as low contact periods and as high rates of flow as the manufacturers can safely recommend. In general, detention periods have been reduced to 1–1½ hours.

The committee, after studying capacity and loadings for more than three years, has reached the general conclusions that this type of installation is particularly adaptable to calcium carbonate precipitation reactions, and that, while it is theoretically possible to produce a softened water chemically stable in calcium carbonate whenever sufficient calcium carbonate surface and time are provided, no evidence has been presented that such chemical stability is generally obtained.

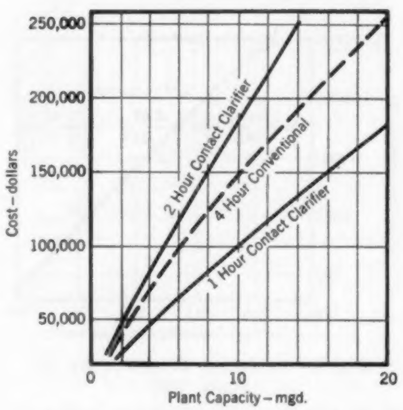


Fig. 8. Comparative Clarifier Costs

The costs of conventional and suspended solids contact clarifiers are based on the E.N.-R. Index of 475 (1913 = 100).

To the committee's general statement the author would add his view that for water with much permanent hardness, particularly if magnesium salts are an important constituent and the supply is drawn from surface sources in the northern part of the United States, detention periods should be considerably lengthened.

* See p. 263, this issue.—Ed.

Obviously any comparison of costs of conventional and suspended solids contact clarifiers is greatly influenced by the detention period as illustrated in Fig. 8, which compares estimated costs of conventional clarifiers with 4-hour settling periods with suspended solids contact clarifiers with both 1- and 2-hour detention periods. In the smaller suspended solids contact basins, the equipment represents about two-thirds of the total cost, the ratio being progressively reduced to about half for the largest units.

Summary

The author believes that:

1. Most public water supplies with a hardness of 125 ppm. or more will eventually be softened.

2. Serious consideration should be given to the installation of softening equipment to supplement purification in new filtration projects designed to purify water of a hardness of 125 ppm. or more.

3. The cost of softening hard water is outweighed by the savings which result from the softening. This is particularly true if softening is installed in conjunction with filtration.

4. Softening can be more economically and satisfactorily accomplished in the public water works than by individual softeners servicing each customer.

5. Usually the water customer who is informed of the comparatively small per capita cost of softening water favors softening the entire public supply.

6. Water softening generally effects a saving for the consumer much greater than its added cost, and makes the community a better place in which to live.

St. Louis Dry Line Chlorinating System

By A. V. Graf and E. E. Easterday

A paper presented on October 3, 1950, at the Missouri Section Meeting, St. Louis, by A. V. Graf, Chief Chem. Engr., and E. E. Easterday, Engr. in Charge of Design & Construction, of the Water Dept., St. Louis, Mo.

IN 1940 the St. Louis Water Dept. was confronted with the problem of adding chlorine, in the Howard Bend secondary coagulation basins, at a point 2,200 ft. from the chlorine control room. Until that time pipelines had been used to transport chlorine solution from the control room to the point of application, less than 500 ft. away, and even with this short line considerable difficulty was experienced with line breaks and other mishaps. Because chlorine solution lines are relatively expensive, it was decided to substitute a less expensive means of application. The dry line chlorinating system now in use at the two St. Louis water purification plants was therefore designed and built.

This dry line system consists essentially of a pressure regulator for the chlorine gas, a rotameter and a control valve in the control room; a steel pipe to carry the dry gas to the point of application, which may be any distance from the control room; and an eductor at the point of application to pull the chlorine gas from the dry line and force it into the water through a short section of chlorine solution hose.

Specifically, the dry line chlorinating system consists of the following parts, as shown in Fig. 1:

1. A weighing scale to check the operation of the system; although not necessary, it is desirable with any chlorination equipment.
2. A gas filter which may be made with a short section of steel pipe filled with *spun glass*.
3. A 0–160 psi. pressure gage to indicate the pressure of gas being supplied by the chlorine cylinder.
4. A chlorine pressure regulator which should be able to maintain pressure at the point at which the rotameter is calibrated (usually 15 psi.).
5. A 0–50 psi. pressure gage to indicate reduced gas pressure.
6. A rotameter for measuring the chlorine gas, calibrated for the pressure to which the gas is reduced (usually 15 psi.), and large enough to measure the maximum dosage.
7. A control valve for setting the rotameter for any amount of chlorine applied, within the range for which the system has been designed.
8. A compound pressure vacuum gage to indicate pressure at the inlet end of the long, dry chlorine gas line.
9. A steel pipe from the meter to the point of application, designed to carry the maximum amount of chlorine required by the plant. The length of pipe now in use at the Howard Bend Plant is 2,200 ft. The line's capacity is designed to carry gas at atmospheric pressure at the inlet end.

10. A vacuum gage on the chlorine line at the point of application.
11. A check valve in the chlorine line, made of hard rubber or some other material that will resist the action of chlorine solution, to prevent water from flowing back into the steel pipe that forms the gas line.
12. An eductor to pull the chlorine gas through the steel line and force it through the solution hose to the point of application. This should also be made of hard rubber or other material that will resist the action of chlorine solution, and should be designed to handle the maximum amount of chlorine which might be required.
13. A water supply for the eductor. Since this supply must be maintained at a fairly uniform pressure, a pressure regulator is desirable to insure uniformity. A saving in water consumption can be accomplished by reducing the pressure on the eductor when smaller amounts of chlorine are required.
14. A check or air inlet valve on the discharge side of the eductor through which air can enter, if the water supply should be interrupted, to prevent water from being drawn from the solution hose into the steel pipe.
15. A solution hose to the point of application. This hose should be kept as short as possible to prevent back pressure on the eductor and to keep the size of the eductor and the amount of water consumed to a minimum.

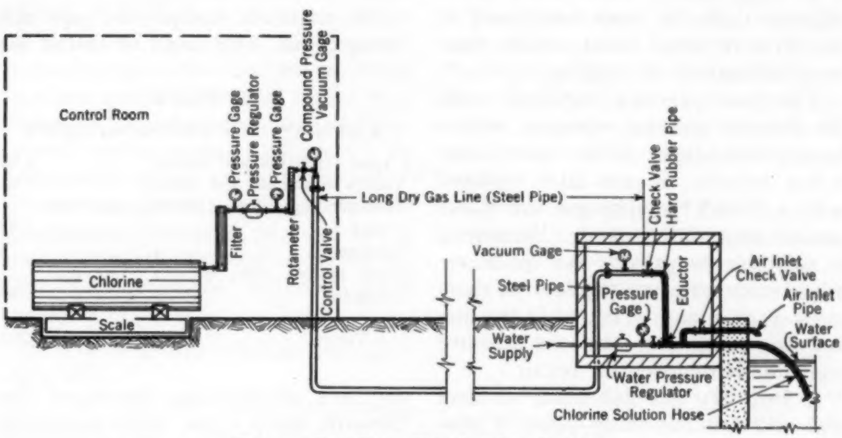


Fig. 1. Dry Line Chlorinating System

At the Howard Bend plant of the St. Louis Water Dept., which uses this arrangement of components, the length of the dry gas line connecting the chlorine control room with the point of application is 2,200 ft., or nearly half a mile.

The eductor, and air inlet or check valve, on the discharge side of the eductor, should be located above the level of the water into which the solution hose discharges. A riser should be provided in the chlorine gas line, just back of and above the eductor, to insure opening of the air inlet valve be-

fore water can reach the steel pipe if the water supply should be interrupted.

During the nine years that this type of chlorinating system has been used in St. Louis, some defects have been discovered and the necessary corrections made.

The spun glass of the filter needs replacing at intervals which depend upon the size of the filter and the quality and quantity of gas used. A filter made of 6-in. pipe, approximately 3 ft. long, passed about 1,000 lb. of chlorine daily for over four years at the Howard Bend Plant, before there were indications of clogging.

The first pressure regulator used for chlorine gas was equipped with a bronze diaphragm which lasted only a few months; it was later replaced with a Monel * diaphragm which has proved more satisfactory. Because it is desirable to provide for quick removal of the pressure regulator, a short piece of pipe may be cut to fit the line and may be inserted when the pressure regulator is removed for repair.

A long dry gas line made of steel pipe will last for many years if protected from outside corrosion. The chlorine pipe line in the Chain of Rocks Filter Plant is over 700 feet long and has given 22 years service without leaking. If a long dry gas line is laid underground it must be protected by a wrapped coating or be encased in cement grout. A leak in this line cannot be detected by the odor of chlorine because it operates at less than atmospheric pressure. Only a drop in the vacuum gage reading will indicate a leak in the line or a reduction in water pressure at the eductor end of the line.

Rubber ball check valves are also used and should be replaced about once each year, as they develop checks on the surface after longer service.

The cost of this chlorination system is relatively small. One can be built for a few hundred dollars, or for as much more as required for better or more elaborate controls.

All materials, except steel pipe and fittings, that were used to install the dry line chlorinating system at the Howard Bend Plant, were purchased for $293, as itemized in Table 1.

TABLE 1

Cost of Dry Line Chlorinating System

Gages (chlorine and water)	$ 67
Valves (chlorine and water)	68
Pressure regulators (chlorine and water)	43
Rotameter	75
Hard rubber pipe, fittings (line and eductor)	40
TOTAL	$293

The amount of chlorine actually applied by the Howard Bend Plant does not deviate more than 5 per cent from the amount indicated on the rotameter. It has varied in excess of 10 per cent but can be kept almost constant if both scale and controls are checked hourly.

The operation of the chlorinating system has been under the direct supervision of William B. Schworm, senior chemical engineer at Howard Bend.

* A product of International Nickel Co., New York.

Capacity and Loadings of Suspended Solids Contact Units

Committee Report

A committee report presented on May 22, 1950, at the Annual Conference, Philadelphia, by H. O. Hartung, Chairman, Committee E5-4—Practical Loading Capacities of Water Treatment Plants. The other members of the committee were: A. S. Behrman, R. W. Haywood Jr., W. H. Knox, W. A. Kramer and C. H. Spaulding. Consultants to the committee were: H. L. Beohner, G. A. McBride, F. G. Nelson and S. L. Tolman.

THE A.W.W.A. Committee on Capacity and Loadings of Water Treatment Processes has confined its study to water purification units of the type designated by the committee as "suspended solids contact softeners," or "suspended solids contact clarifiers." These units (shown in Fig. 1–8, with descriptive information provided by the manufacturers) are being marketed under at least eight different trade names: *

1. The Accelator—Infilco, Inc., Chicago, Ill.
2. The Clariflow—Walker Process Equipment, Inc., Aurora, Ill.
3. The Flocsettler—American Well Works, Aurora, Ill.
4. The Hydro-Treator—Dorr Co., Stamford, Conn.
5. The Liquon—Cochrane Corp., Philadelphia, Pa.
6. The Reactivator—Graver Water Conditioning Co., New York, N.Y.
7. The Spaulding Precipitator—Permutit Co., New York, N.Y.
8. The Worthington—Worthington Pump & Machinery Corp., Harrison, N.J.

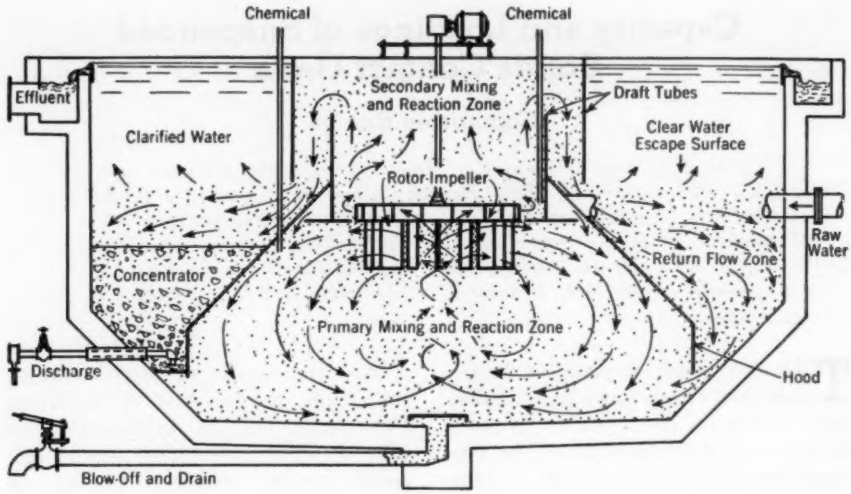
* An additional product now on the market, but not mentioned in the committee's report, is the Clarator, manufactured by Belco Industrial Equipment Div., Paterson 3, N.J.—Ed.

The first report of this committee was made to the A.W.W.A. Water Purification Div. in Atlantic City on May 3, 1948 (1). This report discussed several characteristics of the basins observed by public health engineers.

By further pooling their own experiences and observations, committee members were able to expand the information contained in the 1948 report for presentation on June 2, 1949, at the Chicago Convention, observing that:

[1] An important and valuable characteristic of the suspended solids contact unit is its ability to perform solids contact mixing, coagulation, and solids-water separation, within a single package type basin. The units are particularly useful for "suspended solids contact" processing, suggesting the general name "suspended solids contact softener," or "suspended solids contact clarifier."

[2] The suspended solids contact action makes the units particularly adaptable to softening reactions employing calcium carbonate precipitation. The mechanics of mixing and of solids contact seems to be particularly well suited to these reactions, which require intimate contact for some time



Slurry Pool Indicated by Shaded Areas

Fig. 1. The Accelator—Infilco, Inc.

The Accelator replaces, in a single, compact unit, the previous multiple water conditioning steps of mixing, coagulation and sedimentation. In operation, the chemicals and raw water are introduced into the mixing and reaction zone so that reactions take place in the presence of previously formed solids. There is controlled recirculation of the slurry (several volumes to one volume of raw water) with positive return of solids from the separation zone to the primary mixing and reaction zone. There is dynamic, high-rate separation of a volume of thoroughly treated and clear water from the moving pool of slurry in the return-flow zone by displacement of a volume of raw water. Concentrators continually collect and automatically discharge the excess solids.

The Accelator consists essentially of a basin in which is contained:

1. *A raw water inlet and distribution duct.*
2. *A primary mixing and reaction zone.*
3. *Two concentric draft tubes which form the secondary mixing and reaction zone.*
4. *A rotor-impeller for mixing and pumping, driven by a motorized reducer.*
5. *An effluent launder system.*
6. *Concentrators to accumulate and remove excess slurry.*

between the solution phase and the solids phase to reduce calcium carbonate supersaturation of the treated water.

Committee members agree that although a calcium-carbonate-stable softened water might be possible in this type of unit if sufficient surface and time are provided, no evidence has yet been presented to indicate that such stability is generally obtained. The degree of chemical stability of lime-softened water that is obtained, however, has been observed to be at least equal to that in other type basins.

[3] Suspended solids contact softeners or clarifiers are often installed because of the expected savings in capital and space offered by their package type construction. Apparently the

relatively small area required by the basins has sometimes allowed an appreciable increase in plant capacity through the more efficient utilization of space formerly occupied by other type basins.

[4] An important operating characteristic of the suspended solids contact type basin is the removal of solids in the same quantities in which they are precipitated. To remove slurry in any other amount would result in an increase or decrease in slurry concentration. The permissible variations in slurry concentration and their effect on effluent water quality were not established.

Finally, the committee was able to agree that alum floc in suspended solids contact basins seems to be subject to the same breakage and disintegration from rough handling as alum floc in any other type basin. Calcium carbonate slurries, on the other hand, as generally formed in lime softening, seem to be fully resistant to destruction from agitation. The character of the mixing required in these basins demands the same careful consideration given to that of other mixing and conditioning basins. For example, too violent mixing for too long a time will cause serious floc destruction and result in uncoagulated water. Similarly, mixing or floc conditioning for too short a time will also produce uncoagulated water. Provision for avoiding either extreme is a fundamental consideration in basin design.

The work of the committee following its June 1949 report was based on a questionnaire mailed to approximately 200 operators of suspended solids contact basins. From the replies received, the committee has compiled additional information about the characteristics of the basins.

Value of Reused Floc

The first question the committee asked was whether previously precipitated floc retained in the basins assists or hinders coagulation, results in the use of more or less coagulant, or has any other effect on water treatment plant operation.

The slurry pool or suspended sludge blanket has been variously described as a filtering medium, as a collection of solids for turbidity entrapment, a surface upon which further precipitation will take place or a means of reducing the time necessary for floc coalescence. Whatever the concept, the effect is claimed to aid coagulation materially. The committee has made no attempt to determine or confirm the nature of any chemico-physical reaction which might assist coagulation; its first question was intended only to determine whether a built-up slurry or sludge is of value in coagulation.

That a slurry pool or sludge blanket is essential to proper coagulation is the opinion of almost all the operators replying. Plant operators at Wilson, N.Y.; Barker, N.Y.; Weirton, W.Va.; Williams Bay, Wis.; Sidney, Ohio; Wister, Okla., and elsewhere agree that previously precipitated floc definitely aids coagulation.

The opposing minority's position is summed up by Keller of Pinellas County, Fla., who writes: "Previouly precipitated floc seems to have little effect on the water except when it reaches a quantity large enough to stop circulation, and then it retards color removal and causes heavy carryover of floc to filters. Previously precipitated floc does not greatly affect dosage."

Supporting the majority view, Annen of the Winthrop-Stearns Co., treating Hudson River water in a suspended solids contact clarifier, describes the

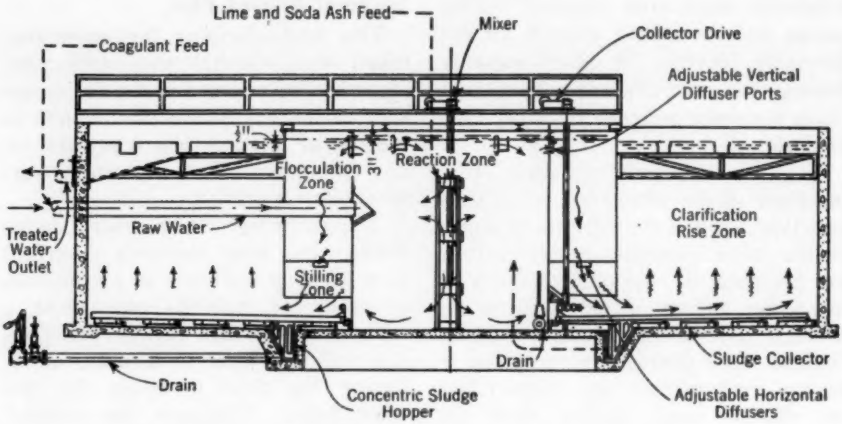


Fig. 2. Clariflow—Walker Process Equipment, Inc.

Mixing in the reaction zone is active, causing homogenization and forcing reactions to completion; this affords excellent bombardment and reaction between recirculated fresh slurry and raw water for softening.

Multiple, closely spaced diffusers distribute flow equally into the top of the flocculation zone in which a rotating and rolling effect affords flocculation. The horizontal diffusers direct the water into the stilling zone to maintain the same multiple equal distribution and rotation. The balanced rotation eliminates "tendencies," or short circuiting.

The homogeneous mixture of water and separable solids flows out across the floor and under-flows the clear, lighter liquid above. Once quiescence is established, sharp separation precipitates floc and allows clarified water to be displaced upward. Bottom slurry thickeners are used to scrape and thicken settled sludge to the blow-off point, minimizing waste water and controlling waste and recirculated sludge. Clear water rises toward the multiple surface overflow as a uniform, vertical rise of clear liquor.

Plant effluent flows (at low velocity of approach) over uniformly spaced multiple weir troughs serving equal areas, thereby aiding average rise rates. Recirculation of freshly formed precipitate for catalyzing purposes is positive and controlled by means of a low head pump carrying fresh slurry back to the reaction zone.

value of previously formed floc as demonstrated in jar test experiments. He has shown "that floc added to a jar for the purpose of forming new floc permits coagulant savings in the new jar. This effect can be seen in a succession of jars, simulating somewhat the recirculating action of the suspended solids contact clarifier." He has not, however, been able to demonstrate the same savings in actual plant practice, for "the plant cannot as yet claim alum doses which are different from those in neighboring plants; it is felt, however, that performance may be improved as the operators become more familiar with the water of the Hudson."

Savidge of the Naples, Fla., water works has tested the value of previously precipitated floc in the clarifier by operating his units both with and without slurry. Discussing the results, he writes that he has "found it very

necessary to maintain a previously precipitated floc to secure proper coagulation. When putting the clarifier in operation after cleaning, it is necessary to reduce the flow and slightly reduce recirculation until a slurry is formed. Once slurry is formed, the flow can be increased to normal rates and the coagulant dose can be reduced. A good slurry pool is necessary for proper coagulation. Proper chemical dosages can be applied and the desired results obtained even if the slurry pool is not correct, but carryover of slurry to the filters will cause them to clog. A slurry of high concentration will also permit the removal of more hardness from the water when softening."

Ehlers of Antigo, Wis., similarly reports: "Sufficient amounts of previously precipitated floc or slurry are needed to assist in proper coagulation and sedimentation in the suspended solids contact softener; considerably smaller chemical doses can then be used in the treating process. Whenever the plant has been shut down for cleaning or repairs, practically all sludge, sedimentation and previously precipitated floc have been removed. When the unit is put back into operation, several days are often required before normal performance can be obtained, and until then a greater than average amount of chemicals is used. The effluent from the softener throughout this starting-up period is not usually good and is very difficult to control."

Douglas of the West Pennsylvania Water Co. similarly observes that "Previously precipitated floc definitely aids coagulation in this type of equipment. Probably the best proof of this statement is the operating difficulty encountered for three to five days after cleaning. During this time, a considerable amount of floc reaches the filters, and the turbidity ranges from 20 to 30 ppm. After three to five days a new sludge blanket forms and the effluent turbidity drops to about 2 ppm."

Gallaher of Appleton, Wis., operating several suspended solids contact softeners, notes that previously precipitated sludge assists in the coagulation of turbidity except in waters which are normally difficult to coagulate. With turbidities that are high or otherwise difficult to coagulate, increasing the alum does not remove all of the fine particles in the upflow basin unit, nor does it put them in a form that will be retained on the filters. But the same effect is noted in the conventional type of plant at Neenah, Wis., which treats the same type raw water. Iron salts have been used in the settling basin following the unit to clear the water.

Davis of Decatur, Ill., also shares the majority view that slurry assists in coagulation. His reservation, however, is that "there is a limit to the usefulness of the slurry, and at a certain age it loses its value completely. Just when this will happen depends upon the character of the floc and its magnesium hydroxide content."

At Jacksonville, Ill., where one of the earliest of the suspended solids contact clarifiers was installed, the lack of any sludge concentrators, either internal or external, prevented Blesse from building a proper sludge blanket when the water was turbid unless unreasonably large quantities of water were bled from the bottom of the basin to waste. It is not surprising, therefore, that he reported unfavorable operating experiences, which might conceivably improve if a proper slurry or sludge blanket could be maintained without incurring large water losses.

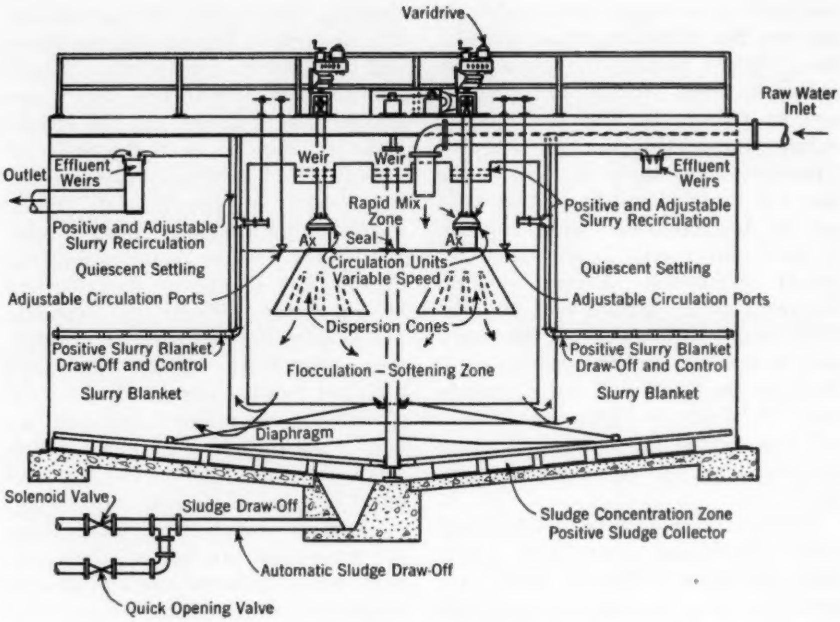


Fig. 3. The Flocsettler Unit—American Well Works

The Flocsettler Unit can be used either for turbidity removal or for softening. It utilizes slurry recirculation, sludge blanket settling, sludge concentration and positive sludge removal, each positive and adjustable. The raw water enters the rapid mix zone and flows through the circulation units into the flocculation or softening zone. Because the rate of flow through the circulation units is adjusted to a capacity greater than the inflow, there is a slight differential between the water surfaces of the rapid mix zone and the quiescent settling zone. A solid baffle through which the circulating units force the water and the recirculated slurry make this differential possible. This difference in hydrostatic pressure provides positive slurry recirculation. The slurry is returned from a point between the flocculation zone and the settling zone and is carried upward in an annular space surrounding the flocculation zone. The amount of recirculated slurry can be positively measured at the point of its overflow over weirs and this rate may be varied by changing the rate of the circulating units.

The flow entering the quiescent settling zone equals the rate of inflow, thereby creating a minimum of disturbance and allowing proper sedimentation. A slurry blanket can be accumulated in order to obtain maximum efficiency. This blanket is kept in balance by automatically removing concentrated sludge from the concentrated sludge draw-off. Positive sludge collection is provided over the entire bottom of the tank but the area immediately under the flocculation zone is separated by a diaphragm which provides optimum conditions for sludge concentration. Settling volume is not decreased by large concentration pockets. The point of entry of the chemicals is in the rapid mix zone just above the circulating units.

Sludge removal from the centrally located hopper at the bottom of the tank can be accomplished automatically by a timer and a solenoid-operated diaphragm valve.

Several contributors point out that, although a previously precipitated floc is essential for successful operation of the clarifiers, the floc or slurry must be of the proper character. For example, Walvoord of Williamson, N.Y., reports: "Previously precipitated floc is necessary to successful operation of a suspended solids contact clarifier, but if there is not sufficient turbidity entering the floc, it will become light and result in a greater carryover to the filters."

Sillence of Owasso, N.Y., experiences some difficulty in building a slurry pool which would remain in the clarifier to coagulate the clear lake water, again, apparently, because of a lack of turbidity to weight the floc. Where this difficulty has been experienced at other installations, such as Lake City and Naples, Fla., the use of activated silica as an aid to coagulation has been successful in permitting the weighting of the slurry pool and in limiting floc carryover.

Rossum of San Jose, Calif., observes that previously precipitated floc materially aids coagulation, but does not believe that such aid results in a coagulant saving. "For adequate coagulation to take place, exactly the same amount of coagulant is required either with or without the slurry. The slurry appears to be of value in increasing the rate of floc formation and settling." On the other hand, Davis of Decatur, Ill., operating both a conventional plant and a suspended solids contact softener, claims that a slurry pool does result in the use of less coagulant. In opposition, again, Milliken of the Oregon State Board of Health, reporting for Wilson, operator of the Albany, Ore., water purification plant, states that "three times as much alum and one and one-half times as much lime is required as when a coagulation basin was used. Better coagulation results, however, and it is assumed that the slurry assists the coagulation."

Whereas slurry or sludge blankets in the suspended solids contact units appear to be a definite aid to coagulation, several operators, such as Heidebrecht of Buhler, Kan., comment that there is a maximum slurry concentration which can be held in a unit; slurry and turbidity exceeding this maximum pass out into the effluent.

Detention Time Required

The size of water purification basins is quite often described in terms of total detention time. Although detention time does not necessarily offer an indication of the working capacity of a basin or unit, it does permit some useful comparisons. Because suspended solids contact units have been generally used as short term detention basins, the committee was interested in learning what field experiences with these detentions have been. To gather the information, the following question was included in the committee's letter of inquiry:

What is the required detention period of a suspended solids contact type basin—for [1] softening, [2] coagulation? That is, on the basis of operating experiences, can you give the minimum desirable detention time required for such processing in these basins?

Replies to this question listed detention periods ranging from slightly less than one hour to approximately three hours. The shorter detention periods could not be related to a particular process, although it would seem reasonable to expect that short detention periods would be used for softening and that longer detention periods would be required in clarification.

Simmons and DeFranco of Weirton, W.Va., both believe that a three-hour detention period is desirable for coagulation, whereas Burrock of the Minnesota & Ontario Paper Co. claims: "The horizontal type suspended solids clarifiers used here were designed for approximately 68-minute detention periods. Experience to date indicates that this is probably the absolute minimum, and that a close control of all adjustments is required to operate at this rate. Most of the operation has been at a rate designed to provide about two hours' detention time, and this has given successful operation."

At the Canton, Decatur and Chandlerville, Ill., plants and at Junction City, Kan., where softening is the major function, an approximately 60-minute detention period has been found satisfactory. Other plant operators, however, report that different detention periods are required, as shown in Table 1, so that generalization is not possible.

TABLE 1

Preferred Detention Periods for Suspended Solids Contact Units

Operator	Detention Periods: Softening *minutes*	Detention Periods: Coagulation *minutes*
Wilson, N.Y.		30–120
Jackson, Ill.	75	
Barker, N.Y.		50–240
Weirton Steel Co.		180
Weirton, W.Va.		180
Naples, Fla.		60 with activated silica
Appleton, Wis.	90	
Canton, Ill.	45	
Williams Bay, Wis.	70	
Eastman Kodak Co.		60
Wister, Okla.		120
Western Cartridge Co.	60–90	
Buhler, Kan.	120	
San Jose, Calif.	80	
Spencer Chemical Co.	90–180	90–180
Antigo, Wis.	60	
Decatur, Ill.	45–60	
Junction City, Kan.	60	
Chandlerville, Ill.	60	
Fergus Falls, Minn.	120	
Avon, Ill.		20
Consolidated Water Power & Paper Co. (Wisconsin Rapids, Wis.)		60–75
Shelby, Ohio	90	
Marshall, Mo.	80	
Minnesota & Ontario Paper Co.	68–120	
Minneapolis, Minn.	90–180	
West Pennsylvania Water Co.	77	
Pinellas County, Fla.		60–120
Kelso, Wash.		60
Parkville, Mo.	50	
Aluminum Co. of America (Davenport, Iowa)		70
Dexter, Mo.	60	
Western Electric Co. (Chicago, Ill.)		90
Standard Oil Co. (Sugar Creek, Mo.)		360
Standard Oil Co. (Richmond, Calif.)		127
Ontario, Ore.	180–300	
Sidney, Ohio	102	
Sinclair Refining Co. (Marcus Hook, Pa.)		60
Weyerhauser Lumber Co. (Longview, Wash.)		60 plus
Esso Standard Oil Co. (Baton Rouge, La.—1)		60
Esso Standard Oil Co. (Baton Rouge, La.—2)		100
Pacific Gas & Electric Co. (San Francisco, Calif.)		90–300
Lebanon, Ore.		180
Albany, Ore.		120
Great Northern Ry. Co. (Allouez, Wis.)	90	90

Gallaher of Appleton, Wis., reports that a suspended solids contact softener cannot be operated in excess of its rated capacity (about 90 minutes), without floc carryover. Apart from this failing, however, softening reactions seem to be complete at rates as

high as 100 per cent overload during the summer months.

Buxton of the Western Cartridge Co., at Alton, Ill., which operates a suspended solids contact unit to soften and clarify Mississipi River water states that: "The best coagulation and softening occurs with a detention period of approximately 1–1½ hours."

Sowden of Fergus Falls, Minn., among others, has pointed out the importance of water temperature in any determination of detention time. He indicates that if water temperature is 33°F., softening should last as long as two hours. Under favorable conditions of slurry contact, however, and with a higher temperature, as little as 30 minutes might suffice to effect proper softening.

Davis of Decatur, Ill., similarly states that during summer weather the units may be operated at 33 per cent above rated capacity to obtain the same results as are obtained during the winter at normal rates. During the winter season a 60-minute detention period permits almost complete softening.

Mellen of Minneapolis, Minn., adds that, in addition to temperature, concentration of reacting reagents plays a part in determining required detention time in the suspended solids contact softeners. He specifies a 90-minute contact period if water temperature is about 50°F., and 2½–3 hours if water temperature is below 40°F.

Douglas of the West Pennsylvania Water Co., operating suspended solids contact clarifiers, presents another point of view in advising that too long a detention period is detrimental to operation. When detention in his units was increased from 77 minutes to 3½–4½ hours, "a higher coagulant dose was required, and even then the effluent water was inferior, with turbidity rising from 2 ppm. to 5 and 6 ppm."

Safety Factors

The problem of operating safety factors formed the basis for the third question asked:

Are the characteristics of the basins such that they provide adequate safety factors when the basins are being operated at, below and above designed capacity?

The majority of those replying to the committee's inquiry state that the basins provide adequate safety factors, if required detention periods are maintained.

Rogers at Wister, Okla., suggests that the operating safety factor for this type of basin can properly be built into subsequent plant facilities. He writes: "The operating factor of safety in this water plant is provided by the large clear well capacity which follows the filters. The suspended solids clarifier has a two-hour detention period and produces a clear water when chemical feed is properly adjusted to the incoming water. The raw surface water, however, is subject to abrupt changes in quality which at times result in sludge carryover. At such times, the plant can be shut down, since the clear well has two to three days' supply of filtered water."

Davis of Decatur, Ill., who operates a suspended solids contact softener in parallel with conventional basins, compares safety factors during mechanical equipment failures. "The same treatment produces a better quality water effluent from the suspended solids contact softeners than from the conventional basins. There is, however, a safety factor during mechanical failure in the conventional type of plant that is not present in the suspended

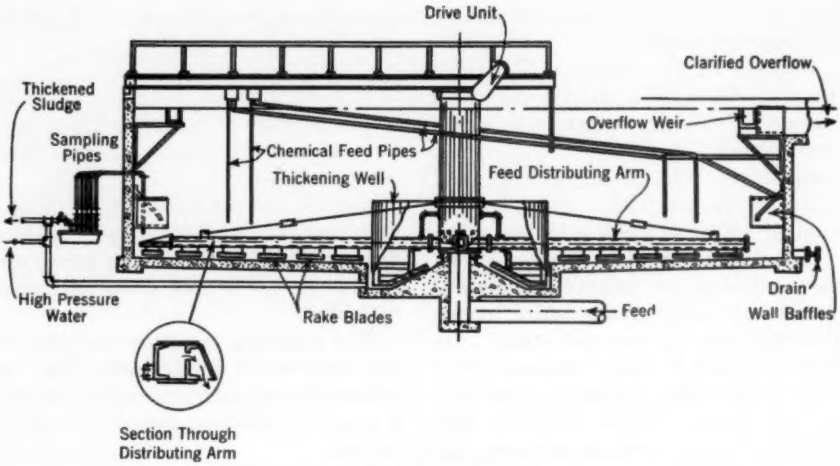


Fig. 4. The Hydro-Treator—The Dorr Co.

The Hydro-Treator is a self-contained, upflow type unit designed for color, turbidity, hardness and algae removal. Three separate zones are provided for the essential steps of flocculation, clarification and thickening. Distinguishing characteristics are: [1] the effective area distribution of feed within a sludge blanket by means of rotating arms with distributing orifices; the sludge blanket being maintained in a state of constant movement by the agitative effect of the rotating arms; [2] provision for the positive and continuous removal of sludge solids from the entire tank floor by rakes attached to the rotating arms; and [3] a central thickening well for the collection and concentration of sludge solids and provision for their positive removal to avoid the accumulation of a sludge blanket of excessive depth.

Each Hydro-Treator is adapted to the particular water to be treated, but the basic design always remains the same. Approximate overflow rates when using alum only, in gpm. per sq.ft. of net surface area, are: for color removal, 0.65 to 1.0; for algae removal, 0.75 to 1.3; for turbidity, 0.75 to 1.3; for softening, 1.5 to 1.9. In general, these rates may be materially increased by the addition of silicates. Although the detention time will vary, the design normally provides for approximately 60 minutes. Operating rates are selected to provide an effluent water turbidity of approximately 5 ppm. Hydro-Treators now in operation range from 4 ft. to 125 ft. in diameter.

solids contact basins. Partial treatment and a sedimentation basin can be employed at such times because of the greater retention period in the mixing basins and clarifiers."

Sowden of Fergus Falls, Minn., operating one of the first suspended solids contact softeners to be installed in the U.S., says: "It is very difficult to maintain continuous operation of these units, and at least two interruptions to service every day are inevitable. During these breaks the slurry bed sinks and it is some time after operation is resumed before slurry is again floating properly in suspension in the unit. Until this slurry suspension is effected, there is a very marked increase in softener effluent turbidity, undoubtedly caused by the violence of

the wheel breaking up already formed floc. Both the influent water rate and the feeding of chemicals must be kept within very close tolerances."

Swanger of Shelby, Ohio, adds: "Water quality is best when the suspended solids contact softener is operated at 75 per cent of designed capacity (for this unit, one hour). A low effluent turbidity cannot be obtained when operating beyond rated capacity."

Maurer of Sidney, Ohio, similarly reports, "At designed capacity, the safety factor is rather small. A change in floc characteristics rapidly upsets plant efficiency, and corrective methods become effective slowly. As the rate of flow decreases, however, the effect of such changes decreases proportionately."

Keller of Pinellas County, Fla., who reports a two-hour optimum detention period, finds that, "in general the basin provides adequate safety factors except for highly colored, slightly turbid and alkaline water, which tends to form a light fluffy floc. To allow for this difficulty, a basin should be designed with an overcapacity of at least 25 per cent. The problem does not seem to arise when treating lake and well supply mixtures. Low turbidity waters appear to allow high carryover of floc at designed capacities, resulting in bad color, high chlorine demand and the necessity for excess filter wash water."

Milliken of Oregon, discussing information obtained from Vaughan at Lebanon, Ore., points out that the suspended solids clarifier at Lebanon is designed for three-hour detention at rated capacity. Maximum use of this unit has been at a rate only two-thirds of capacity. With the high turbidity, results have been satisfactory. The safety factor would not be considered adequate, however, if the unit were operated at designed capacity. Milliken also secured data from Wilson, operator of the Albany, Ore., plant, where the designed detention of the clarifier

TABLE 2

Quantities of Waste Water

Operator	Portion of Total Water Treated	
	In Softening *per cent*	In Clarification *per cent*
Aluminum Co. of America (Davenport, Iowa)		12
Antigo, Wis.	1.7–2	
Appleton, Wis.	¼–½	
Barker, N.Y.		1–3
Chandlerville, Ill.	½	
Consolidated Water Power & Paper Co. (Wisconsin Rapids, Wis.)		3–5
Dexter, Mo.	0.5	
Eastman Kodak Co.		4
Esso Standard Oil Co. (Baton Rouge, La.—1)		10–18
Esso Standard Oil Co. (Baton Rouge, La.—2)		5
Kelso, Wash.		0.5–0.7
Marshall, Mo.	1–1½	
Minneapolis, Minn.	2	
Minnesota & Ontario Paper Co. (International Falls, Minn.)		0.5–1
Naples, Fla.	0.1	
Parkville, Mo.	5	
Pinellas County, Fla.		4
San Jose, Calif.	<1	
Shelby, Ohio	7	
Sidney, Ohio	4	
Sinclair Refining Co. (Marcus Hook, Pa.)		1
Spencer Chemical Co. (Pittsburg, Kan.)	¼	3
Standard Oil Co. (Richmond, Calif.)		0.03–0.07
Standard Oil Co. (Sugar Creek, Mo.)		10
Weirton, W.Va.		1–3
Weirton Steel Company (Weirton, W.Va.)		1
West Virginia Water Service Co. (Princeton, W.Va.)	0.5	
Western Electric Co. (Chicago, Ill.)		4
Williams Bay, Wis.	1.8	
Williamson, N.Y.		1–2
Winthrop-Stearns Company (Rensselaer, N.Y.)		3.7

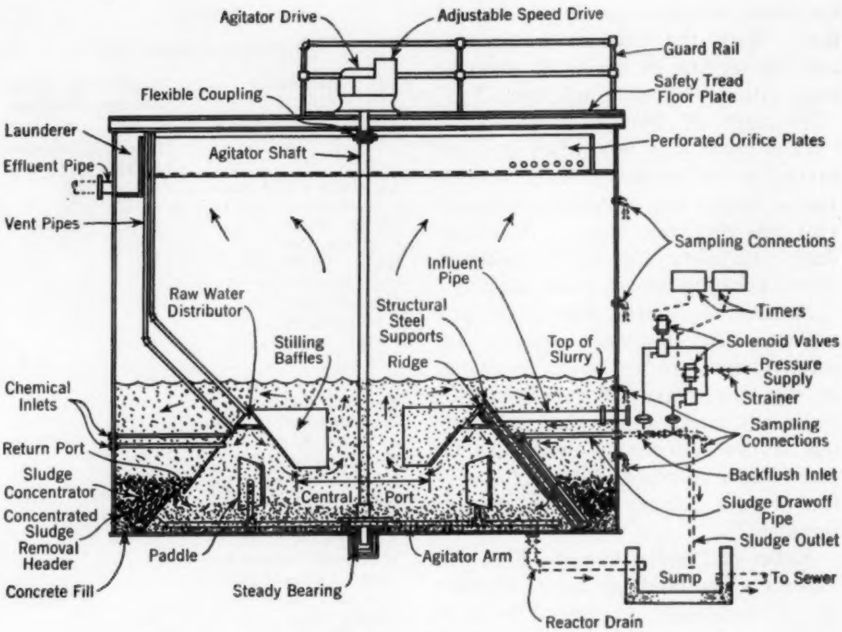


Fig. 5. The Liquon Cylindrical Reactor—Cochrane Corp.

Two zones are provided in the Liquon Reactor, the mixing zone below and the clarifying zone above, separated by inclined baffles. The raw water is uniformly distributed into the mixing zone through a perforated plate located under the ridge of the baffles. After the clarified water separates from the sludge bed it is collected evenly by the off-take system near the top provided with submerged orifices.

The chemicals are introduced at the point where the raw water enters so that the chemicals, raw water and heavy slurry are mixed simultaneously with a minimum of delay, eliminating the formation of smaller size floc in the interval.

The variable speed agitator, across the entire bottom of the reactor, with upright inclined blades, insures a uniform slurry mixture avoiding any deposit on the bottom. The slurry passes upward through the central port. Rotation of the mass is stopped by the stilling baffles and the slurry then moves laterally, some settling in the sludge concentrators, but the greater part returning to the mixing zone through sludge recirculation or return ports. The greater density of concentrated sludge above the return port causes this return flow. A separate path for the return of sludge to the mixing zone is important because then it does not have to return downward against the high upflow velocities which prevail through only one port.

After passing up through the central port the slurry spreads across the full top area of the tank, none of the area being lost by any baffles in the clarifying zone. Thus the lowest possible velocity is provided to separate the sludge from the water. Spilling over the ridge of the baffles into the sludge concentrator, the slurry settles and thickens because it is outside the zone of agitation. It is automatically withdrawn at intervals through a diaphragm-operated valve. The desludging is either controlled by a program-timer or proportioned to the raw water flow by connection with the flow meter on the influent line.

is two hours. This is not considered an adequate safety factor, as considerable difficulty is experienced in keeping the sludge blanket down when operating at rated capacity with temperatures below 40°F.

Douglas of the West Pennsylvania Water Co. points to the mechanics of maintaining a sludge level as safety provision for these units. "Although this basin has been operated at only 80 per cent of designed capacity, it is felt that the safety factors are adequate. By using an automatic or manual draw-off system, the sludge blanket may be maintained at almost any level desired. In operating at a varying rate of flow, it is desirable to carry the sludge blanket at a lower level in order to insure a greater margin of safety. If the rate of flow is constant, however, the sludge level may be carried higher without affecting the effluent turbidity.

"In addition to the draw-off system, the variable speed agitator also provides a measure of safety. Aside from its function of mixing, it helps, in conjunction with the upward flow of water, to hold the sludge blanket in suspension. Thus, by regulating agitator speed, the sludge blanket may be raised or lowered as desired."

Aerni of the Aluminum Co. of America at Davenport, Iowa, expressed a similar point of view in stating that the factor of safety is adequate, provided there are proper adjustments of equipment to maintain a proper sludge level.

Waste Water

Whether the quantity of waste water from these units comprises an important operating cost, was also considered by the committee. The question put to water treatment plant operators follows:

What is the quantity of waste water? That is, when the basins are operating at designed capacity, what per cent of water flowing into the basins is used for sludging and other operations?

Replies to this question seem to indicate that the amount of water waste in these units is very similar to that in other types of water treatment devices. Where sludge is composed primarily of calcium carbonate, there appears to be very little waste water. Plants which coagulate surface waters containing turbidities, however, report higher water losses. In Jacksonville, Ill., where the suspended solids contact clarifiers were constructed without sludge concentrators, the water losses were prohibitive. Table 2 summarizes the replies which were received to this question.

Effect of Varying Amounts of Slurry

To determine the effect of varying amounts of slurry on turbidity removal, softening and other chemical reactions, another question was formulated:

What is the effect of varying amounts of suspended solids (slurry) on completeness of chemical treatment and on turbidity in the effluent water? (For example, does softening improve when the slurry concentration is high? How high? Similarly, does turbidity removal improve when slurry concentrations are high? How high?)

The general response indicated that although a slurry is necessary for coagulation, its exact concentration within allowable limits is not too important. It does appear that softening improves as the suspended slurry concentration increases, although with

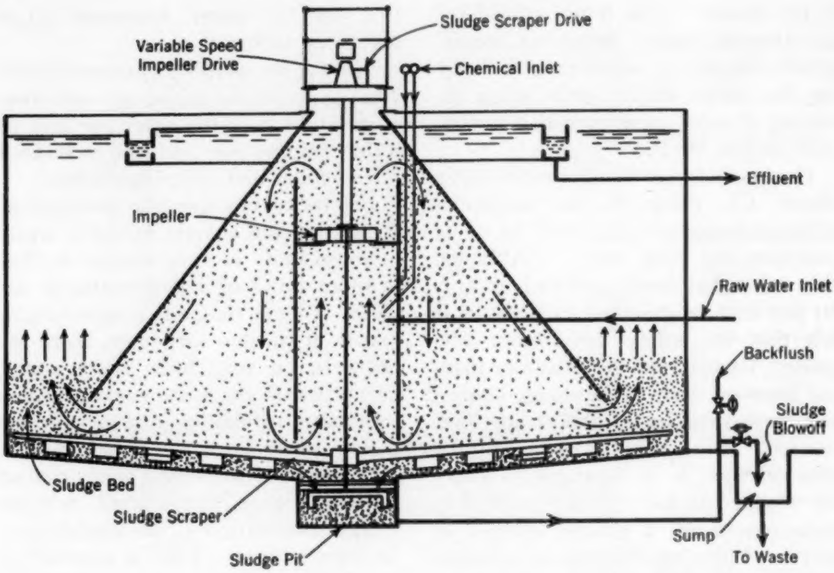


Fig. 6. The Reactivator—Graver Water Conditioning Co.

Each Reactivator is individually designed for the specific water characteristics and operating conditions prevailing at a given plant. Data applying to the great majority of installations may be summarized in general form, however.

The Reactivator is used for both coagulation and softening. It ranges in diameter from 10 to 125 ft., and the outer tank may be of steel or concrete, either circular or square. Chemicals may be added to the raw water either in the central uptake tube, before or after the circulator, or at the raw water line.

Total retention time is 60 to 120 minutes. Rising rates may vary in coagulation from 1.0 to 2.0 gpm. per sq.ft. of surface (in the settling zone), and in softening from 1.5 to 3.0 gpm. Recirculation is effected by a mechanical impeller or air lift at 3 to 5 times rated capacity.

Sludge scraper tip speed varies from 8 to 10 fpm. Sludge concentration ranges from 5 to 25 per cent by volume in the mixing zone, from 20 to 50 per cent in the settling zone, and from 95 to 100 per cent at the blowoff point. Five minutes' settling is provided. The average blowoff rate varies from 0.5 to 2 per cent of the flow rate.

The sludge bed level is normally maintained 8 to 10 ft. below the surface. Effluent turbidity is guaranteed not to exceed 10 ppm., and average effluent turbidity is maintained below 5 ppm. Flow rate can increase from 0 to 100 per cent of rated capacity in 5 to 10 minutes without exceeding 10 ppm. turbidity in the effluent. Sludge can quickly be resuspended following a shutdown.

very high concentrations slurry carryover is a problem.

For example, Smith of Barker, N.Y., operating a suspended solids contact clarifier, reports: "Although the amount of suspended solids varies, there is no noticeable turbidity in the effluent at any time. When the slurry is composed of larger particles, turbidity removal is greater."

Annen of Winthrop-Stearns Corp. writes: "Slurry concentrations held to about 10 per cent (volumetric 5-minute-settled test) produce the best results. Floc carryover increases at high slurry concentrations (about 15 per cent), but these are attributed to a volume too large for the slurry pool, rather than to incomplete reaction."

Walvoord of Williamson, N.Y., obtains best turbidity removal when the volume of slurry is between 3 and 5 per cent.

Simmons of the Weirton Steel Co. and DeFranco of Weirton, W.Va., both believe that increased quantities of suspended solids in the suspended solids contact clarifier improve turbidity removal. As DeFranco says: "Turbidity removal improves when slurry concentrations are high. Exactly how high, the summary of plant records is too incomplete to indicate.

Klinger of the Consolidated Water Power & Paper Co., who operates a suspended solids contact clarifier for color removal, reports: "Fluidity of slurry seems to be a limiting factor. It is not beneficial to allow floc to remain too long because it may pack."

Rossum of San Jose, Calif., found the suspended solids contact clarifier ineffective when slurry concentration was too low and sludge coming over the weir when the concentration was too high. "Within the fairly wide operating limits of the unit, the effluent clarity appears to be independent of slurry concentration."

With only a few exceptions, the softener operators agree that softening improves as the slurry concentration increases. For example, Gallaher of Appleton, Wis., states: "Softening efficiency is greatly reduced if the concentration of sludge in the slurry pool is below the optimum. In order to obtain proper results the concentration by volume must be kept at 9 to 10 per cent. Better removal is obtained at the higher sludge concentration."

Walvoord at Williams Bay, Wis., says: "Increasing the amount of suspended solids makes chemical treatment more complete."

Wardrep of Jefferson City, Tenn., has measured the improvement he gets in softening with a high sludge concentration. "Softening improves from 4 to 6 ppm. when slurry concentration is high."

Swanger of Shelby, Ohio has also attempted to evaluate the effect of varying concentrations of slurry in his unit. "The efficiency of softening reactions is definitely affected by suspended solids concentration in the slurry blanket. A suspended solids concentration of 4 g. per l. in the slurry blanket has proved to be the best concentration for all-around operation. This concentraiton gives good softening efficiency and lowest effluent turbidity.

"When suspended solids concentration decreases to 1 or 2 g. per l. in the slurry blanket, softening efficiency decreases and turbidity increases.

"When suspended solids concentrations in the slurry blanket reach 8 to 10 g. per l. softening efficiency is not decreased but the slurry blanket comes too high and there is heavy particle carryover into the effluent. There is a definite range of suspended solids concentration in the slurry blanket for each type of water treated and for each type of treatment. This range is found only through experimental work on the particular case at hand."

Operators generally agree that, because of other operating difficulties, the slurry concentration which can be carried in the softening units must be

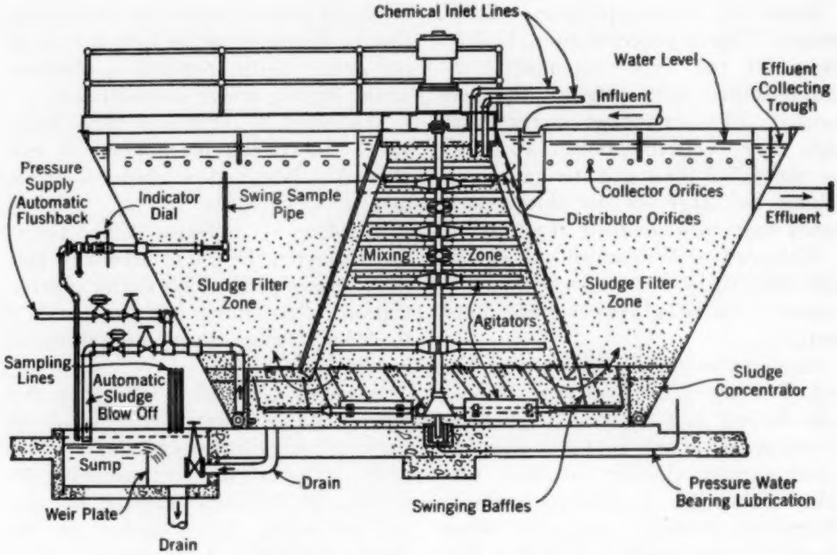


Fig. 7. Vertical Spaulding Precipitator—The Permutit Co.

Incoming raw water and chemicals are rapidly and intimately mixed in the upper part of the mixing zone, in contact with previously formed precipitates maintained in suspension by the slow speed agitator. Thus, nuclei are present in a suitable form to insure growth of large, dense sludge particles. As the water flows downward through the mixing zone, the particles are further enlarged and strengthened by the slow rolling agitation. Near the bottom of the Precipitator, the direction of flow reverses, and the water and sludge pass upward through the restricting port. Above this point, the upflow area increases, with a consequent reduction in velocity, until the sludge particles are no longer carried upward. A clearly visible line of demarcation results, above which the clarified water continues to rise to the effluent collector system. Uniform effluent collection is obtained by the use of submerged orifices which avoid the need for accurate leveling required by weirs.

There is a continuous recirculation of particles from the sludge filter zone back into the mixing zone, caused by the suction of the agitator blades passing below the port. This counterflow maintains approximately the same concentration of sludge in both the mixing and upflow zones. The sludge concentrator provides a zone in which sludge can settle quiescently, and be withdrawn intermittently with a minimum waste of water. Regulation of blowoff is best accomplished by a photoelectronic control which automatically maintains the sludge blanket at a predetermined level regardless of variations in flow rate or raw water composition. Alternatively, an adjustable timer can be used to control the blowoff.

The lower blades of the agitator sweep the entire bottom of the mixing zone, preventing settling of sludge during operation, and readily resuspending settled sludge after shut-down periods. A four-speed motor drives the agitator, thus providing flexibility in the degree of agitation. The entire weight of the agitator is supported from above. A water-lubricated guide bearing is used at the lower end of the shaft. Swinging baffles located in the restricting port prevent the rotational motion imparted by the agitator from reaching the upflow sludge filter zone.

limited to a given maximum. Most of the committee's correspondents point out that when slurry concentrations are high, there is a corresponding deterioration of effluent water quality due to turbidity.

Pilot plant studies made in 1941 of the suspended solids contact softener utilizing Meramec River Water near St. Louis demonstrated that the softening yield per unit of lime added was materially improved by increasing the slurry or sludge concentration to more than 1 to 1½ per cent by weight, with detention and agitation remaining constant. When slurry concentrations within the unit equaled approximately 4–6 per cent by weight, nearly stable water, as measured by the calcium carbonate stability test, could very often be produced. When slurry concentrations within the unit exceeded 1–1½ per cent, however, the slurry pool, or sludge bed level, remained near the surface and considerable turbidity appeared in the effluent water. Slurry concentrations as high as 5–6 per cent by weight caused the basin effluent to become extremely turbid with sludge. On the whole the tests indicated to the investigators that laboratory calcium carbonate stability tests could be reproduced in the units by maintaining a slurry concentration of 5 per cent or more by weight. To do so would be impractical, however, unless the basins were followed by conventional sedimentation basins designed to remove carryover from the softener.

Winters, discussing the New Iberia, La., Plant, makes a somewhat similar observation: "It was found after many determinations that optimum results are achieved when the consistency of the suspended solids sludge is maintained between 1 and 1.6 per cent by weight and the slurry bed is kept approximately 72 in. below the surface of the water. Too low a concentration of sludge produces a water of good clarity, but supersaturated with calcium carbonate. If a sludge of more than 1.6 per cent is allowed to develop, turbidity develops, although the water is generally quite stable."

Buxton of the Western Cartridge Co. is of the same general opinion. "Until a given maximum is reached, suspended solids removal and softening improve as slurry concentration increases. Beyond the optimum, however, pin-point floc and carryover occur."

Eller of Junction City, Kan., says "The suspended solids contact softener will not work satisfactorily with either extremely high or extremely low concentrations of slurry. Optimun results are afforded by a 20–30 per cent concentration by volume following 5 minutes' settling. The best way of determining whether the blanket is correct is by observing it from the top of the unit."

Sowden of Fergus Falls, Minn., claims that the mixing of the sludge is perhaps more important than its concentration. "The concentration of solids is not as important as proper agitation to obtain maximum contact of calcium carbonate particles within the sludge and calcium carbonate ions in the water being treated.

"Experience has shown that wheel speed should be kept as high as possible without causing carryover of slurry into the effluent trough. During peak periods of the summer when the plant is being operated as its maximum rate of 3 mgd., slurry concentration drops as low as 0.5 per cent solids."

Davis of Decatur, Ill., indicates that there are limits to slurry concentration which are imposed by mechanical or settling considerations. "The

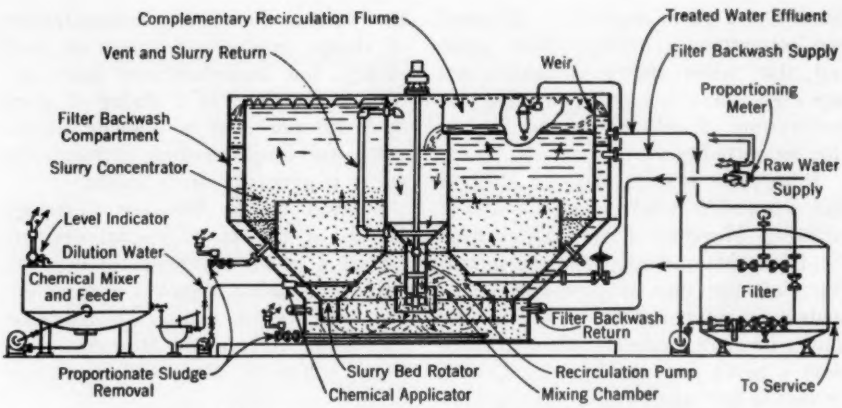


Fig. 8. The Worthington—Worthington Pump and Machinery Corp.

The "CM" type water softener and coagulator can be used for softening and flocculation without any change in design, although for flocculation the size is greater to permit lower release rates to accommodate the lighter alum floc. The "CM" design is applicable to unit capacities of from 700 to 2,500 gpm., and employs mechanical energy distinguishing it from the "CH" design, which employs only hydraulic energy. This type is suitable for lower capacities, where pressure loss is not of great consequence. Regardless of load variation, a constant velocity through the slurry bed is maintained by recirculating an amount of treated (but unfiltered) water in inverse proportion to the treated water demand.

If filters are used in softening, an annular compartment may be provided for backwashing them with clear water without loss of water and without disturbing velocities of the water under treatment. This is accomplished by drawing the wash water from the upper area of the wash water compartment and simultaneously returning it to the lower area. Clarification of this water is accomplished by settling within the compartment.

Sludge removal is not only automatic, but volumetrically proportionate to raw water input to the softener.

higher the concentration of solids which can be maintained in the reactor chamber, the more complete the softening will be. There is a limit to this concentration, however, imposed by the settling out and sealing off of recirculation. With proper treatment, a high concentration is not needed for turbidity removal."

Organic Solids in Slurry

Sludge return processing is not practiced in certain conventional treatment plants using surface waters, because of the resulting taste and odor and chlorine demand problems. One of the questions which the committee wished to resolve on the basis of field experiences was whether any similar problem existed with the suspended solids contact units. The inquiry follows:

What is the effect of the sludge blanket or slurry pool obtained from surface supplies containing organic matter, on taste and odor and chlorine demand?

Widely opposing experiences with the effect of organic material in the slurry pool or sludge blanket were reported to the committee.

Buxton of the Western Cartridge Co. at Alton, Ill., treating Mississippi River Water, states that, "The sludge blanket has an important effect in removing taste and odor, but it cannot be said to vary the chlorine demand very much."

Davis of Decatur, Ill., claims: Taste and odor offer less difficulty in the suspended solids contact basin than in a conventional plant, as the pH quality of the slurry can be better controlled than in a clarifier or settling basin."

Rossum of San Jose, Calif., believes that organic material has no effect. "Although the San Jose supply is obtained from the Sacramento River which is highly contaminated and contains considerable amounts of organic material, no effect has been noted on taste and odor or upon chlorine demand."

Opposing this point of view is Faery of Wilson, N.Y., who estimates that a slurry pool necessitates a 50 per cent increase in the chlorine used.

Mautino of Canton, Ill., also finds that "the chlorine demand is greater and there is a more pronounced taste and odor in the slurry when organic matter is present."

Winters, discussing the New Iberia plant, states: "Taste and odors are likely to develop whenever basins are not cleaned often enough. A thorough cleaning of the tank at New Iberia is made at regular intervals; generous use of activated carbon has also been found helpful, particularly during the summer months."

Prechlorination is used to control algae at the New Iberia plant. As chlorine (added to the raw water after aeration) had been used in the old basins with good results, it was also introduced in the new up-flow reservoir. Two things immediately became apparent: [1] the chlorine dosages ordinarily used had to be increased as the suspended sludge created an additional chlorine demand, and [2] the chlorine was causing a great deal of turbidity in the suspended solids contact clarifier effluent. The increased chlorine demand problem was easily resolved by increasing the chlorine dosage. The cause of turbidity, it was learned, was a too rapid oxidation of the ferrous iron in the raw water, which resulted in an aerated water lacking in sufficient cogaulant. After some experimentation a point of application within the central pyramid was found where coagulation could be properly and effectively applied.

Gallaher of Appleton, Wis., offers a possible explanation of and solution to taste and odor and chlorine demand problems in these units: "When organic matter is present, taste and odors may result from the accumulation of sour sludge in the blanket. This may be prevented either by the elimination of dead spots so that no sludge in the blanket is retained indefinitely, or by use of activated carbon."

Sowden of Fergus Falls, Minn., offers another solution: "During the time of year when tastes and odors are a problem, carbon is fed directly into the influent of the suspended solids contact basin and is therefore trapped within the slurry. It has been noted that when carbon is not added to the influent for a time, tastes and odors increase noticeably after water has passed through the suspended solids contact basin, probably as a result

of the entrapment of organisms within the slurry. These become concentrated in number and die, giving off their essential oils, thereby increasing tastes and odors."

Taylor of Ontario, Ore., observes: "Organic material in the sludge blanket will, without proper prechlorination, cause the blanket to become sour and carry over, resulting in an effluent turbidity of from 100 to 200 ppm. A sludge blanket loaded with decomposing organic material is always a breeding place for tastes and odors."

Milliken of Oregon writes, regarding the Lebanon, Ore., plant: "The sludge blanket reduces tastes and odors, but does not completely remove them. Activated carbon is used to aid this process and chlorine demand is consequently lessened." Also, "Taste and odor removal is definitely improved. There is no noticeable effect, however, on subseqent chlorine demand, compared with standard coagulation basins."

Chemical Feed Interruption

What is the effect of interruptions of chemical feed on basin performance?

This question was designed to determine what happens to slurry within the unit when chemical feed is interrupted for varying periods. One group indicates that there is no serious effect upon water quality resulting from short interruptions of chemical feed.

For example, Faery of Wilson, N.Y., claims that no changes in water quality occur if interruptions last no more than 10 to 15 minutes. Similarly, DeFranco of Weirton, W.Va., says: "Interruptions in chemical feed have little effect on the effluent water coming from the basins; the interruptions never last more than two hours, however."

O'Fallin of Forrest City, Ark. claims that "if the chemical feed interruption lasts from a few minutes to a half hour it will not hurt the operation as the slurry pool will 'cushion' the interruption."

Trowbridge of Chandlerville, Ill., reports a change in effluent water characteristics but no serious basin upsets. "Interruptions of chemical feed cause slowly rising alkalinity and total hardness. As this change is quite slow—provided the feed is not interrupted for too long—no serious change will result."

Sowden of Fergus Falls, Minn., likewise supports this point of view. "The interruption of coagulant feeding seems to have no effect if the period of interruption is not too great. Any stoppage of lime feeding is accompanied by an increase in turbidity and an increase in finished water hardness."

Burrock of the Minnesota & Ontario Paper Co. agrees with those that do not regard short interruptions of chemical feed as serious. "Basin performance is not affected by short interruptions in chemical feed. If the interruptions are of sufficient duration to change the pH appreciably, coagulation will be adversely affected."

Rossum of San Jose, Calif., offers a possible explanation for the basins' behavior. "Experience has indicated that if an overdose of coagulant is fed for a few hours, coagulation will continue for a short period even though coagulant feeding is discontinued."

In the opposing camp, several operators indicate that even short interruptions in chemical feed were seriously detrimental to the quality of the effluent.

Blesse of Jacksonville, Ill., expressed himself tersely: "An interruption in chemical feed is 'rough.'"

Aerni of the Aluminum Co. of America, at Davenport, Iowa, expands this point of view. "The effect of interruptions of chemical feed on basin performance is immediately evidenced by the loss of the sludge blanket and carryover of previously precipitated floc. A fairly long period is required to build up the sludge blanket again to obtain proper filtering with high turbidity in the effluent water."

Annen of the Winthrop-Stearns Co. reports that, "Chemical feed interruptions produce an upset of slurry pool level and high carryover less than 30 minutes after stoppage. It requires one to two hours—longer in the winter—to build up effective slurry concentration after such a disturbance, or after draining."

Smith of Barker, N.Y., asserts that if chemical feed is discontinued for more than half an hour, the suspended solids contact clarifier must be shut down until the slurry pool has been rebuilt.

Gallaher of Appleton, Wis., says, "If alum feed is reduced below the optimum, an immediate increase in hardness and cloudy effluent results. Decrease in lime feed to the point at which there is no excess results in a cloudy effluent."

Hackett of Williams Bay, Wis., similarly reports: "Interruptions of chemical feed result in a loss of slurry and complete disruption of plant operation."

Bailey of the Eastman Kodak Co. is also in general agreement: "If the alum feed is stopped for only 10 minutes, there is a noticeable carryover of floc to the filters and a deterioration of the blanket itself. Clay and lime feed interruptions do not have such a marked effect on the blanket, but will also cause trouble."

Buxton of the Western Cartridge Co. says: "If a chemical feeder fails in its operation, the entire sludge bed becomes roiled and mixes with all the water in the softener."

Crenshaw of the Spencer Chemical Co. says: "An interruption of chemical feed for more than fifteen minutes will cause serious upset of the sludge blanket."

Ehlers of Antigo, Wis., reports: "Interruptions in chemical feed have a very definite effect upon the performance of the suspended solids contact softener; such effects are apparent both chemically and physically. In order to keep a close check on the water being treated, therefore, the operators are required to make alkalinity titrations on the softener effluent at 20 minute intervals."

Davis of Decatur, Ill., declares, "Interruptions in chemical feed will cause an upset in the sludge blanket; if this condition persists for an hour or more, the blanket will be lost entirely."

Milliken of Oregon writes that at Lebanon the sludge blanket goes over the weir within one hour after interruption of the chemical feed. He also reports that at Albany, Ore., there is a very noticeable loss of sludge blanket in fifteen minutes to an hour.

Swanger of Shelby, Ohio, offers the following additional observations: "Interruptions of chemical feed have a definite effect on the operation of a suspended solids contact softener used in lime soda softening. The effect is not noticeable when the interruption is of short duration, but it does become apparent if the interruption continues for any length of time. The particles in the slurry blanket become smaller when lime or alum doses become and remain too low. Effluent turbidity will then increase and soften-

ing will decrease. Variations in soda ash feed have less effect than lime or alum."

Winters, discussing both the New Iberia and Crowley, La., plants, calls attention to the effect of an interruption of chemical feed on the sludge level. "It has been noted in both plants, that whenever there has been an interruption of chemical feed there has been a decrease in sludge density with a corresponding rise in the height of the suspended sludge."

Floc Carryover

Unit performance can be judged by measuring the turbidity of the effluent water between any well developed, removable floc particles, and also the amount of floc carryover in the effluent water. Because suspended solids contact basins are high rate units, the committee was interested in learning if there is any appreciable floc carryover in the effluent water, even when the water between the floc particles was properly coagulated and of low turbidity. To obtain this information, the following inquiry was included in the questionnaire:

What is the amount of floc carryover and its effect on subsequent filtration when the basins are operated at or near their designed rates?

Most correspondents replied to this question that floc carryover, under average conditions of operation, is relatively unimportant. Usually it is very slight, particularly when the basins are operated within the specified detention periods. Floc which does carry over from the basins to the filters seems to be, as a rule, readily filtered, allowing a clear filter effluent water. On those few occasions when appreciable quantities of floc or slurry reached the filter and chemical dosage had been adequate, the only really important adverse effect, generally speaking, seemed to be in shorter filter runs.

As Davis of Decatur, Ill., puts it: "When operated at 33 per cent above rated capacity, the plant produces, from a raw water with a turbidity of 250–300 ppm., an effluent with 1–3 ppm. turbidity. Higher turbidities cause an increase in carryover. The concentrator capacity of the basin will handle up to 750 ppm. and produce an effluent of 10 to 15 ppm. Beyond this point, difficulties are experienced."

Trowbridge of Chandlerville, Ill., writes: "This basin can be operated at peak capacity without serious floc carryover if the slurry concentration is between 10 and 20 per cent by volume. Higher concentrations cause high carryover and short filter runs."

Sowden at Fergus Falls, Minn., reveals a somewhat different point of view. "The floc carryover very seldom falls below 30 ppm. at the designed rate. This, of course, shortens filter runs."

Keller of Pinellas County, Fla., similarly maintains: "When the unit is operated close to its designed rate, larger carryover and higher wash water rates occur. This is more noticeable with lake water than with lake and well water mixtures."

Floc carryover offers no problem to Gallaher of Appleton, Wis.; a settling basin follows the suspended solids contact softener at this plant and "any settleable floc carried over from the sludge contact basins settles in this basin." A similar situation exists at Minneapolis, Minn. Mellen writes: "Effluent turbidities at rates close to design have ranged from 20 to 60 ppm. The water is conditioned by the application of a coagulant and by settling

before sand filtration." Both these reports suggest possible basin layouts in which very high sludge concentrations are needed in the suspended solids contact softener to produce chemical stability. The floc or slurry carryover from the softener settles out in the secondary basins, thereby proventing any overloading of the filters.

Pratt of Process Engineers, Inc., reports a very interesting observation made at Pittsburg, Calif., on the effect of sunlight on floc carryover. "The slurry level is 7–10 ft. below the surface, usually between 8 and 9 ft. Little variation will occur in 24 hours. The operators report that the slurry level appears to drop at night and on cloudy days, and to rise again when sunlight returns. They do not feel that the slurry level can be controlled, as its characteristics are determined by the hydraulic design of the unit. The slurry usually expands and overflows the weirs at least once every 24 hours; this will last from ½ to 2 hours. Because it is accompanied by no apparent or consistent circumstance which might explain the phenomenon, no means have been devised to control it."

Rate of Flow

Another question asked was:

What is the effect of changes in the rate at which water is pumped into the basins upon the quality of the effluent water when the basins are operated at designed rate, at half of designed rate and so on?

Here again two opposing points of view were revealed. One was summed up by Davis of Decatur, Ill., who reports: "Rate of pumping has no effect upon operation. One can go from 50 per cent of rated capacity to 133 per cent without any effect upon the operation or the efficiency of the units. Of course, the waste water flow must be controlled in proportion to pumpage and solids to be removed." Aerni of the Aluminum Co. of America, at Davenport, Iowa, expressed almost the same view. "There is very little change in the quality of the effluent water when the basins are operated at or below designed rates. This statement, of course, is predicated on changes being made in operating equipment when flow rates change."

Ehlers of Antigo, Wis., also wrote: 'Experience has shown that the suspended solids contact softener can be operated at a rate of from 15 per cent over to 45 per cent under the designed maximum with very good results. Any deviations in the rate of flow would, however, make some change in the effluent quality until detected by chemical analyses and corrected by adjusting the feed machines."

The suspended solids contact softener at the West Pennsylvania Water Co. filter plant is designed to adjust to sudden changes in flow. Because water levels are controlled automatically by "on" and "off" pump operation, the influent rate into the unit is constantly changing. Douglas says of this operation: "When the plant is pumping 1,000 gpm., the rate of flow through the basin varies from 1,350 to 480 gpm. and back again to 1,350 gpm. within a 20–30 minute interval. This is quite a pronounced variation, but the suspended solids contact softener absorbs the shock with ease, and the effluent turbidity remains constant. The only effect of these sudden changes seems to be a slight variation in the level of the sludge blanket."

Mellen of Minneapolis, Minn., also operating a suspended solids contact softener, affirms: "The plant is rarely operated at its designed rate, because

the basin capacity is greater than the demand. At half the designed rate, the effluent is not adversely affected by moderate rate changes."

Faery of Wilson, N.Y., stresses the need for properly regulated chemical feed to accommodate changes in flow.

Several operators claim that the units can be subjected to changes in flow rates, but point out the need for changes in mixing speed commensurate with the change in flow rates. A typical report was received from Pratt of Process Engrs., who in describing the suspended solids contact clarifier at Pittsburg, Calif., wrote: "Although this unit operates at a fairly uniform flow rate, it has been found necessary to increase the rotor speed when the rate of flow increases above normal. This adjustment insures sufficient recirculation for effective flocculation." Buxton of the Western Cartridge Co. at Alton, Ill., has also observed: "The rate at which the suspended solids contact softener is operated, within designed limits, does not in any way affect quality as the speed of the distributor arm is regulated to conform to the normal flow."

Gallaher of Appleton, Wis., operates two different makes of suspended solids contact softeners. In one, changes in rate have no apparent effect on the quality of the effluent, provided the designed capacity of the unit is not exceeded. In the other, agitation speeds must be varied in inverse ratio to the rate of flow in order to obtain best results.

Eller of Junction City, Kan., has been able to compensate for changes in rates of flow by presetting the chemical feeders to accommodate the new rate 15–30 minutes ahead of the rate of flow change. Presetting the chemical feeders to provide for this change produces very good results, he says.

Other operators have indicated the desirability of avoiding all sudden increases in rates of flow. As Burrock of the Minnesota & Ontario Paper Co. reports: "Sudden increases in influent rate are apt to result in some floc carryover to the filters. Unless the increased rate is foreseen and the volume of sludge is decreased accordingly, a greater volume of floc may be carried into the sludge blanket at the low rate than can be carried at the higher rate."

Bailey of Eastman Kodak Co. advises that changes in rate of flow should be made slowly: "When the rate is decreased from the designed rate, a small improvement can be noticed in the quality of the water. When the rate is increased from less than designed capacity to designed capacity, the increase must be accomplished slowly to prevent upsetting the sludge blanket and thus lowering effluent quality."

Hazelquist of the Weyerhaeuser Timber Co., treating Columbia River water in a suspended solids contact clarifier, has found, with low turbidity water, that best operation is obtained when rotor speed is reduced.

A few operators have suggested the inadvisability of trying to operate the suspended solids contact basin at too low a rate. Crenshaw of the Spencer Chemical Co. expresses this point of view. "Due to the inherent design of this unit, it is not practical to operate at lower than half the designed rate. Below this value, water is not distributed by the rotating header over the full area of the tank bottom. It may be brought from half to full rate in 500-gpm. increments every 30 minutes." Klinger of the Consolidated

Water Power and Paper Co. asserts that changes in rate of flow are less objectionable when the unit is operating at designed rate than when it is operating at half the designed rate. "Sizeable surges at half of the designed rate seem to be more of a problem than at the designed rate, the reason being that slurry is usually thinner at lower rates and more difficult to keep in proper suspension."

Changes in Raw Water

An inquiry parallel to the previous question was stated as follows:

What is the effect of frequent and rapid changes in influent water characteristics upon the quality of effluent water?

Those answering this question usually referred to their previous answers about changes in rate of flow, stating that the effect was very much the same.

Pratt, describing the suspended solids contact units at Martinez, Moss Landing, Pittsburg and Port Chicago, Calif., concludes: "Because of the short detention periods used, sudden changes in the physical or chemical character of raw water can be disrupting unless detected soon after their occurrence. Sudden changes in flow have definite hydraulic effects on the suspended slurries or sludges, expanding them as the flow increases. Operators prefer gradual increases for this reason."

Buxton of the Western Cartridge Co. requires the operators to make two-hour tests of influent water chararteristics and consequent necessary adjustments in chemical dosages. At Decatur, Ill., Davis says: "Frequent changes in the character of the raw water treated will naturally call for changes in chemical treatment and solids removed. Operators check the raw water every hour, if the weather indicates that there might be a change. Any material change will call for a change in treatment."

Rogers of Wister, Okla., finds that frequent and rapid changes in the characteristics of the incoming water will upset the operation of the plant, and result in floc carryover too extensive to be handled by the filters.

Aerni of the Aluminum Co. of America at Davenport, Iowa, is able to deal with changes in raw water turbidity if such changes are not too rapid. "Suspended solids contact clarifier effluents are consistently obtained with turbidities of less than 10 ppm. whether the raw river water has turbidity of 20 ppm or 600 ppm. . . . Frequent and rapid changes in influent water characteristics can be handled with very little change in the quality of the effluent waters if the change is not completed within a three- or four-hour period. Approximately that much time is required for the coagulant to take effect and for the sludge blanket to be built up within the basin."

The final question submitted by the committee was:

To what extent are the suspended solids contact clarifiers applicable to highly turbid waters?

The majority of the correspondents had no experience with highly turbid waters, and therefore did not answer this question. DeFranco of Weirton, W.Va., reports no difficulties with basins operating with a 300-ppm. turbidity in the influent water. Walvoord of Williamson, N.Y., similarly claims that a 300-ppm. turbidity causes no difficulty in his unit.

Gallaher at Appleton, Wis., although reporting little difficulty with high tur-

bidities, states: "Alum does not handle high turbidities well; activated silica might be used if the problem were constant. As it is not, troublesome turbidity is reduced by the use of iron salts used in the post settling basin."

Mautino of Canton, Ill., whose lake water reaches a maximum turbidity of 200 ppm., says: "Highly turbid water interferes with the functioning of the suspended solids contact basin because the turbidity settles to the bottom of the basins; under these conditions proper treatment cannot be secured. To clarify the turbidity a great deal more aluminum sulfate must be used and the amount of water treated must be reduced."

Buxton of the Western Cartridge Co., treating Mississippi River water at Alton, Ill. (maximum turbidity—8,000 ppm.), states: "This plant's experience indicates that the suspended solids contact clarifier of the type in use is eminently satisfactory for highly turbid water when operated as designed."

Voorheis of the Esso Standard Oil Co. at Baton Rouge, La., has obtained satisfactory clarification in the suspended solids contact clarifier when the raw water from the Mississippi River had a turbidity of 2,500 ppm.

Crenshaw at the Spencer Chemical Co. similarly observes: "The upflow basins at this installation take water directly from the river intake; records show that results have been satisfactory up to 3,000 ppm. of turbidity. It is believed that installations likely to encounter high turbidities should be preceded by primary basins."

Although it is well known that turbidity in a basin influent does not afford a complete measure of the suspended solids load on that basin, the conclusion of Davis at Decatur, Ill., should be of general interest: "Without presettling basins for turbidities of 1,000 ppm. or more, conventional treatment is preferable. The arrangement at this installation is such that the conventional plant can be used for pretreatment and settling of high turbidity, and the suspended solids contact basins for finishing treatment. The units will not handle highly turbid water (1,000 ppm. or over)."

Wardrep of Jefferson City, Tenn., treating a raw water with turbidities up to 400 ppm., does not think the units are suitable for water continuously that turbid. "The operating cost of this type of basin for highly turbid water would be prohibitive."

Other Operating Experiences

The committee in its inquiries to water treatment plant operators sought to discover other operating experiences which would be of use in compiling its report. Davis of Decatur, Ill., who sometimes operates a suspended solids softener in parallel with a conventional type plant, reports: "Bacterial removal is more complete with the suspended solids contact softener than with the conventional plant."

Rossum of the California Water Service, San Jose, Calif., writes: "This installation consists of a suspended solids contact clarifier of 3-mgd. capacity and a conventional plant of 6-mgd. capacity. On the whole, the performance of the suspended solids contact clarifier has been very satisfactory. The clarifier produces a noticeably superior effluent with the same chemical dose, although its initial cost is very much smaller than a conventional plant of the same

capacity. On the other hand, the operators had to learn how to operate it, and must give more attention to its operation than to the conventional plant. About twice a year the sludge blanket is lost and satisfactory water cannot be discharged to the filters for about 24 hours. The quality of the filtered water, however, has always been satisfactory."

Bailey of Eastman Kodak Co., treating Lake Ontario water, says: "If prechlorination is not enough to give a free residual in the suspended solids contact clarifier effluent, there is a noticeable deterioration in the sludge blanket, causing large carryover and poor floc formation, and resulting in a light, unstable blanket."

Other Reports

In addition to information received from water treatment plant operators, the committee has also availed itself of the experiences of public health and consulting engineers with the suspended solids contact units.

Leaver reviewed the operations of suspended solids contact clarifiers at Ilwaco, Eatonville, Longview and Kelso, Wash. He reports that when chemical dosage and rates of flow are fairly constant, "generally satisfactory water is obtained." On the other hand, the clarifiers do not lend themselves to treatment of water requiring changes in chemical dosages as do standard settling basins.

Blumberg of California has written: "It has been demonstrated that these units can produce satisfactory water for filtration if they receive frequent and intelligent attention, and are not subject to sudden changes in flow. Because no treatment unit is any better than its operator, it is important that the operator should be able to handle the unit at all times."

Muegge of Wisconsin says: "The upflow or sludge blanket type of unit functions effectively when used in softening plants. Insufficient experience with units of this type prevents offering any opinion of their suitability."

Gidley of West Virginia comments: "The upflow solids contact units appear satisfactory for softening and iron removal, but the manufacturer's ratings are too high. The units are believed satisfactory for turbidity removal with some surface water supplies, but the retention period should be at least 2 hours. Installation should be made only where a skilled chemist or technically trained operator is available."

A number of suspended solids contact units have been installed in Illinois. The experience of Klassen of the Illinois Health Dept. is therefore of particular interest. "Illinois now has more installations of these high-rate basins treating surface waters than well waters. About half of the surface water installations are provided with some type of pretreatment, such as that performed by a presettling basin, so that at times of excessively high turbidity, the water applied to the basins may be kept within the necessary limits for satisfactory operation. No difficulties have been observed in the treatment of ground waters containing iron. If magnesium is high, excess lime must be applied to obtain the proper degree of softening. The procedure is substantially the same as in conventional treatment. Such waters produce sludge containing a high proportion of magnesium hydrates which are lighter than calcium carbonate. Proper adjustment of the sludge

concentration and judicious use of coagulant usually make it possible to produce a basin effluent of satisfactory clarity, prior to recarbonation or acid stabilization and filtration."

Devendorf of the New York State Board of Health indicates that experience with suspended solids contact clarifiers has been good. He reports, in addition: "If the turbidity of the raw water changes rapidly, care must be exercised in operating this type of coagulation and settling equipment or inferior coagulation will result. It is thought, however, that these inferior results differ in no way from those which would be obtained from normal coagulation and settling if coagulant feed were not adjusted to meet the demand of the raw water."

Cox, also of New York, adds: "All of the upward flow basins used in New York State so far have given gratifying results, although they are not operated by trained chemists or engineers. These results have been secured in spite of rapid changes in the character of the raw water. District health engineers observing the operation of these units have concluded that they are as flexible and satisfactory as conventional sedimentation basins. This department is inclined to believe, however, that the effectiveness of the clarification achieved with this unit has encouraged underdesign on the part of the manufacturers, and acceptance of this situation by many designing engineers. Obviously, any delay in coagulation caused by low water temperatures or inadequate coagulant dosage would result in the passage of floc from a unit in which the total period of treatment, including flocculation and clarification, is only 60 minutes, as compared with the several or more hours afforded by conventional basins. This department therefore advocates the use of somewhat larger units, and a reduction in the designed rate of flow when smaller plants are under consideration, to assure a total period of 1½ hours."

Beck of the Alabama State Board of Health offers the following information: "Minimum requirements adopted by the Alabama State Board of Health do not permit the use of sludge blanket water purification equipment for treating surface water. This equipment may be used only for mineral removal and softening. For bacterial and turbidity removal from surface waters, it is required that the settling basins have a theoretical detention period of 6 hours, based on a permissible filtration maximum of 2 gpm. per sq.ft. of sand area."

Farrell of Tenn. states: "Unsatisfactory experiences with early models of this type installed in public water supply plants have resulted in the disapproval of this type of equipment for coagulation and sedimentation of water from surface sources. The state does not have any units of this type treating well water supplies; however, there are three units in operation which treat water from surface sources."

Ehlers of the Texas State Dept. of Health writes: "An upflow basin of the type installed at Mineral Wells, Georgetown and Temple, requires more skilled operating attention, than do conventional sedimentation basins. Furthermore, the upflow basins are subject to more operating failures than the conventional basins and produce less satisfactory results with water supplies of varying chemical and physical characteristics. The policy of the department has been to limit approval of

plans for upflow basins to installations in which the raw water supply is obtained from ground water sources. The department does not object to the use of these basins for treatment of a surface water supply if the city involved insists on its installation and the manufacturer of the unit will provide a five-year performance bond. The latter requirements are waived, however, if the retention period of the upflow basin, or the combined sedimentation facilities of the plant, is at least six hours."

Although the committee is not aware of any widespread use of the units as completely automatic water treatment plants, the following statement from Poole of Indiana should be of interest. "One thing is certain. Upflow basin plants cannot be converted into automatic robots which will run themselves. This is especially true of clarification plants. With all the automatic equipment available, the operator must still devote his time and skill to the process."

A. P. Black of the University of Florida, who has had a good deal of experience with these units in Florida and elsewhere, writes: "These units were originally designed for water softening by the lime or lime-soda process, and when so employed they provide, possibly better than the older units, the theoretical conditions under which the reactions involved can approach completion. They do not, however, appear to offer any theoretical advantage over the older units for coagulation."

Ordelheide, of the Missouri State Division of Health, asserts: "The equipment functions best as a softener of high calcium bicarbonate water of low magnesium content, or if the degree of softening desired does not necessitate removal of magnesium. With water of this type, more softening per unit of lime can be obtained than in conventional basins. The units should be confined to softening plants where the raw water quality is constant, the pumping rate uniform and water temperature relatively constant. A supplementary settling basin to receive the effluent from the upflow unit is desirable, for even under the best of conditions these units are tricky in performance. At present, the division is approving the equipment for softening, but not for the clarification of surface waters."

References

1. HARTUNG, H. O. *Solids-Contact Process Basins.* Jour. A.W.W.A., **40**:10:1028 (Oct. 1948).

Amperometric Residual Chlorine Recording

By George J. Hazey

A paper presented on October 26, 1950, at the Michigan Section Meeting, Detroit, Mich., by George J. Hazey, Chief Operator, Water Filtration Plant, Wyandotte, Mich.

MORE than two years have passed since the original installation of a residual chlorine recorder at the Wyandotte filter plant. One year of operation sufficed to convince the plant operators that, at last, an instrument was available for adequate and accurate control of the chlorination process for water purification. The installation was the first in the state of Michigan and the first to be used with raw water containing a high degree of sewage and industrial waste pollution.

The instrument takes a small, continuous sample of the water to be tested and, by measuring a function of the chlorine residual in the water, records the residual value directly in parts per million on a 24-hour chart. This affords both a continuous, visible indication of the residual and a daily chart which may be filed as a permanent record. The instrument can be used to operate signal lights or an alarm system to indicate any given maximum or minimum residual. A remote residual indicator can be used to give direct residual readings at a point or points some distance from the instrument. The instrument measures either the total chlorine residual or the free available chlorine residual, but it does not feed or control the chlorine. The recorder values are set and periodically checked by means of an amperometric titrator.

The source of raw water is the Wyandotte Channel of the Detroit River. The channel, which is approximately 1,000 ft. wide, and about 30 ft. deep at the intake pipe location, carries only 26 per cent of the total river flow, but this includes practically all of the shore line pollution. Because Wyandotte is immediately south of the industrial empire of Detroit, it receives industrial wastes from a wide variety of sources. Phenolic type compounds are ubiquitous, and an indication of the sewage pollution is given by the coliform index, which varies from 2,300 to 1,000,000 per 100 ml. Turbidities average 25 ppm. and reach a maximum of 290 ppm.

Treatment

Production at Wyandotte averages 5 mgd., and the water is treated by free residual chlorination, coagulation with liquid alum, and, after mixing in a basin with over-and-under type baffles, is settled and filtered. Chlorine dioxide is applied after filtration.

When the temperature of the raw water is 55°F. or higher, no difficulty is experienced with chlorophenols. Below this point, however, difficulties begin, and the problem is intensified as the temperature drops. If the pollution remained constant in its concentration, it could be easily treated, but the problem is complicated by the fact

that it is impossible to predict when the pollution will reach the plant, what its concentration will be, or how long it will last. Pollution will usually arrive in "slugs" which are characterized by increased concentrations of oils, phenolic pollutants and ammonias, and which can last from five minutes to 48 hours.

Prior to the installation of an amperometric recorder, the staff of the Wyandotte plant found it impossible, for practical reasons, to make continuous studies of the concentrations of various types of waste. Because of the variability of these concentrations, the studies would be of no use in control practice. A considerable number of samples would have to be analyzed to determine peak loads, and the time required for the analyses would permit too much undertreated water to pass through the plant. In analyses that were made, however, phenol was found to average between 50 and 150 ppb. and the ammonia concentration to vary from 0.03 ppm. to as high as 0.50 ppm. Because no representative analyses could be made, the basic laboratory work was confined to confirming factors affecting chlorine residuals, ammonia concentrations and the presence or absence of a strong medicinal taste or odor in the finished water. The chlorine demand of the water, on the basis of chlorine required to give 0.50 ppm. free chlorine residual at the plant tap, ranged from 16 to 120 lb. per million gallons of water (2–15 ppm.). Normally chlorine dosages were changed 15 times daily, with a peak of 36 times.

Chlorine dioxide treatment was positive in its action for the removal of chlorophenols, but again there was no means of control. The concentration of chlorophenol could not be measured, nor was a rapid and positive test for residual chlorine dioxide available. Tasting the water afforded the only test that could be used under these conditions.

Plant Operating Control

Both the orthotolidine and the orthotolidine-arsenite tests were used to determine chlorine residuals, although at first no constant relationship could be established between taste and type of residual. Because of the rapid fluctuation of the chlorine demand, correlating the test findings with the various sampling points in the plant, such as the mixing chamber, the

TABLE 1

Chlorine Residual Seven Minutes After Application

Time	Residual	
	Free	Total
	ppm.	*ppm.*
1:00 A.M.	1.10	1.60
2:00	1.10	1.70
3:00	0.90	1.60
4:00	0.90	1.60
5:00	0.90	1.60
6:00	0.60	1.40
7:00	0.90	1.60
8:00	1.10	1.70
9:00	0.90	1.60
10:00	0.90	1.50
11:00	1.00	1.60
12:00	1.00	1.70
1:00 P.M.	1.00	1.50
2:00	1.00	1.60
3:00	1.00	1.60
4:00	0.70	1.40
5:00	1.70	2.00+
6:00	0.80	1.40
7:00	1.20	1.50
8:00	0.90	1.40
9:00	0.40	1.20
10:00	1.60	2.00+
11:00	1.70	2.00+
12:00	1.70	2.00+

applied water at the filters and the tap water, proved rather difficult. To offset these difficulties, an intensive residual check program was set up at the mixing chamber, the water being sampled after four minutes' contact with the chlorine. It was found, with this method, that, although the total chlorine residual was about the same, the free chlorine residual varied considerably, as shown in Table 1.

The tests also indicated that a free chlorine residual of less than 0.90 ppm. at this point in the mixing chamber would produce a water with chlorophenolic taste and odor. They indicated too that a much closer check would have to be made on the chlorine demand to determine just when it changed and to what degree, during a 24-hour period. Figure 1 shows how chlorine dosage is affected by changes in chlorine demand.

It was found, in studying the chlorine demand graphs, that the greatest changes in chlorine demand followed a daily time pattern, occurring shortly after 3:00 P.M., but that they varied in degree. Instead of checking residuals every hour, therefore, checks were instituted at 15-minute intervals after 3:00 P.M. The results were surprising, and showed all types of flash demands of short and long duration, usually within the original hourly chlorine checks. The new routine helped considerably to eliminate unpleasant tastes, but, at a 5-mgd. rate, a delay of even 15 minutes can allow a great deal of water to go untreated for taste and odor control. Furthermore, although the period of greatest difficulty was taken care of, it was difficult to keep operators checking residuals constantly and to maintain plant operations as well. All of the water could not be overtreated in order to guard against sudden changes. Fortunately, the operators were able, after some experience, to judge quite accurately the dosage of chlorine needed to maintain a free residual during the difficult periods.

What was needed at this juncture was some method which would reduce the time required for a continuous residual check, and so enable all demand

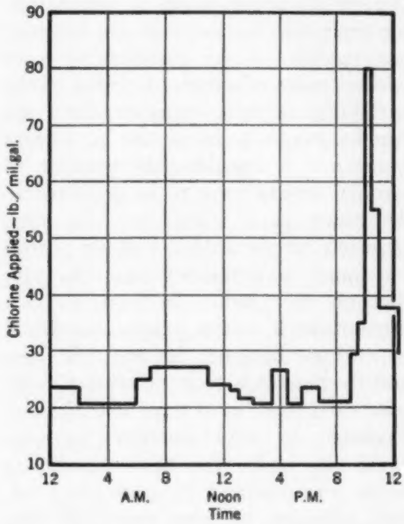


Fig. 1. Chlorine Demand of Raw Water
The variability of chlorine demand is greatest after 3 P.M. each day, and extreme changes in dosage may be required to cope with the fluctuations.

changes to be noted and corrected as quickly as they occurred. It was felt that, if this could be accomplished, the problem could be solved by chlorine, and the need for chlorine dioxide treatment reduced. The cost of chlorine is, after all, 10.25¢ per pound (in 150-lb. cylinders), whereas the cost of chlorine dioxide is 86.25¢ per pound. A reduction in cost would undoubtedly be

desirable; however, the primary concern remained the elimination of undesirable tastes and odors.

The Residual Recorder

At this point it was felt that the Wallace and Tiernan amperometric residual chlorine recorder might provide the most complete solution to the problems encountered. Two major difficulties presented themselves, however. First, to use the mixing chamber as a sample point would involve deposition of alum floc on the electrodes, thus affecting the operation. Second, the high turbidities of the Wyandotte water supply would probably plug the recorder's residual measuring cell. To eliminate alum coating of the electrode, the application point of alum could be relocated to obtain a sample which was only chlorinated. Although no definite answer to the turbidity problem was found, it was finally agreed that the instrument should be put into operation as the best means of determining its efficiency. The installation, under the supervision of Wallace & Tiernan Co. engineers, was made on October 5, 1948. The recorder was placed on the tap water line to familiarize the staff with the operation of the instrument. Figure 2 shows the recorded residual chlorine. The fairly uniform line presents proof that the additional vigilance given to frequent sampling at the mixing chamber was paying dividends. Figure 3 outlines the variable chlorine demand of the raw water for the same period.

Following a short period of operation, tests in raw-water sampling were begun. A pump was installed to maintain the flow and pressure required. The sample point selected followed chlorination but preceded application of alum. The recorder functioned perfectly at first, but suspended material in the water gradually plugged the electrode cell and reduced the water flow required for accurate residual measurement. It must be borne in mind that, as this was the first installation ever made under the conditions prevailing at Wyandotte, it was not known what dirt in the water would do to the electrode. After experimenting with many types of filters, the Cuno * metal filter, which could be cleaned in operation either by hand or motor, was found to work best. The motor-driven method was the one selected because it could be set to operate intermittently or continuously, as the need required. After its installation, there were no further difficulties due to turbidity.

The sample supply line from pump to recorder was arranged so that the pump would deliver water to the filter, and from the filter to the residual measuring cell assembly. The balance of unfiltered water was to be bypassed through the bottom of the filter. This method of operation affords two definite advantages: it maintains a constant flow from the pump, thereby reducing the flow time from point of sampling to point of recording, and it maintains a continuous flushout of materials removed by the filter. The filtering problem was conquered. At no time was there any trouble with the recorder itself. The instrument is checked weekly, the sample pump is overhauled twice a year and the filter is renewed once a year at minor cost. Figure 2, the recorder chart of a day's run, shows where the residual dropped below the 1.0-ppm. alarm point and how quickly recovery was effected.

As stated previously, 0.90 ppm. free chlorine residual at the mixing chamber

* A product of Cuno Eng. Corp., Meriden, Conn.

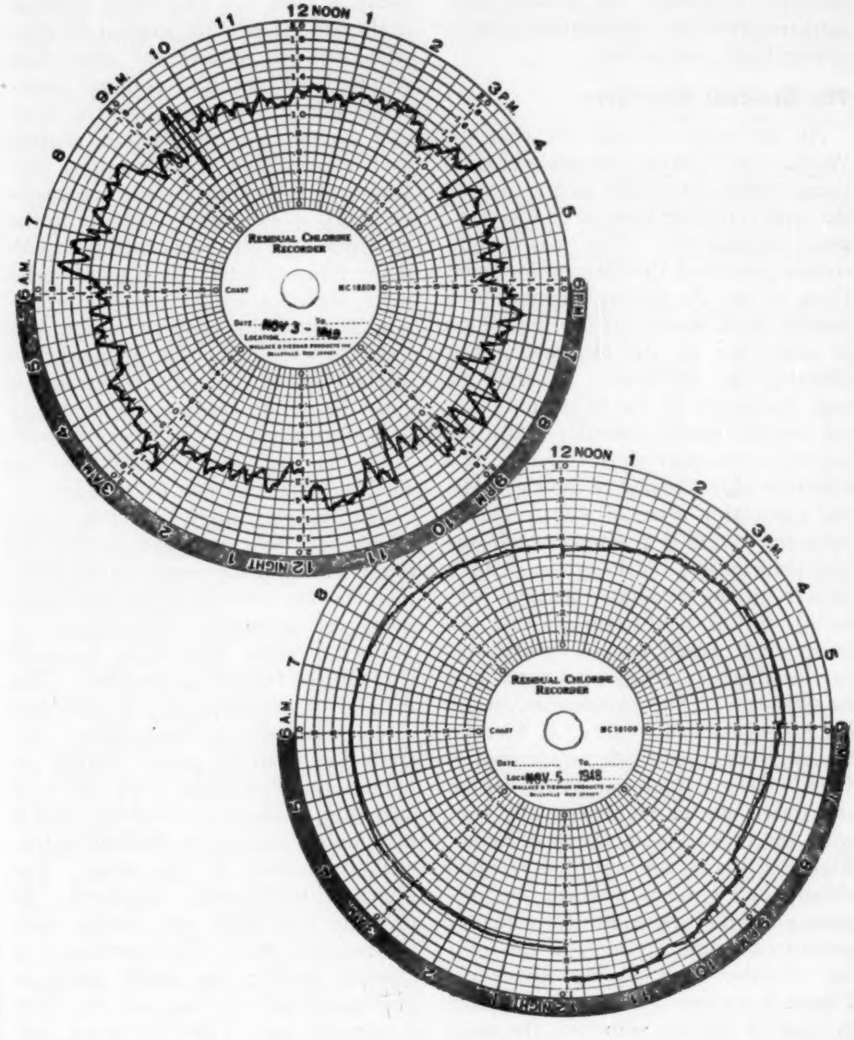


Fig. 2. Residual Chlorine Records

Permanent records of the residual chlorine in the finished water are provided by 24-hour charts. The relatively uniform residual in the lower chart indicates how effectively variations in chlorine demand of the raw water, shown in Fig. 3, were being controlled. The top chart illustrates how quickly recovery was effected after the residual dropped below the 1-ppm. alarm point.

sample point gave a finished water without chlorophenol taste and odor. To allow a safety factor, 1.0 ppm. was designated as the danger point for control, and the alarm system was adjusted accordingly. Any time that the residual drops below this point the alarm system alerts the operator to the change in the chlorine demand of the raw water. After adjusting the chlorine dosage, the operator need only watch the progress of the residual on the recorder chart. Only three minutes are required to show residual change on

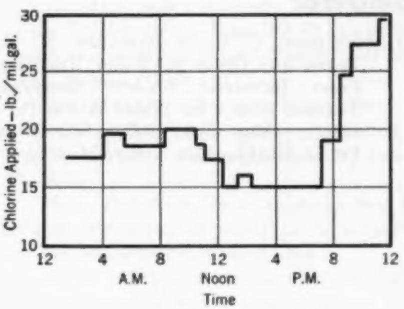


Fig. 3. Chlorine Demand of Raw Water
Considerable variations in dosage were required to produce the residuals recorded in the top chart of Fig. 2.

the chart after the chlorine dosage is changed. If necessary, the time element can be reduced still further, a decided improvement over the earlier method which involved making many residual determinations by time-consuming colorimetric methods, and which was subject to difficulties from combined chlorine and interfering agents. The plant's operators have placed complete reliance in the residual recorder, and, with its aid, they have done a magnificent job of eliminating undesirable tastes and odors in the finished water.

Benefits

A number of benefits can be attributed to the use of the residual chlorine recorder at Wyandotte. These can be enumerated as:

1. Elimination of chlorophenolic tastes and odors.
2. Accurate recording of free chlorine residual, in parts per million, in daily, permanent form.
3. Prechlorination control which is visible at all times.
4. The recording of sudden changes in raw water demand for future checks.
5. An instant alert of operating personnel, by means of an alarm system, to any sudden changes in the raw water chlorine demand.
6. An even residual maintained throughout plant.
7. Reduction of chemical costs by the avoidance of overtreatment.
8. A check on operating personnel chlorination practice, such as the increasing of chlorine dosage before increasing pumpage rate and the decreasing of pumpage rate before reducing chlorine dosage.
9. Prevention of chlorophenolic tastes and odors by means of chlorine at less than the cost of chlorine dioxide treatment.
10. The maintenance of a free chlorine residual at all times, regardless of the intensity of the slugs, without resort to jar tests for chlorine demand and to analyses for phenolic or ammonia concentrations.

Ruchhoft and Ettinger (1) give a very interesting outline of the problems involved in maintaining a free residual when phenolic pollutants and ammonias are variable in concentration. They also state that chlorination for chlorophenolic taste removal might not be easy and would require care-

ful and continuous laboratory control. The author certainly agrees that the problem is difficult. Operating experience has proved that unless free chlorine exists above the breakpoint, with the phenols and ammonias reduced to zero, chlorophenolic tastes and odors are present. It was also found, incidentally, that rechlorination of chlorophenols is ineffective.

Two years of experience with automatic residual chlorine recording has substantiated the writer's faith in chlorination control at the mixing chamber, immediately after the chlorine is applied. Control of chlorination for the prevention of chlorophenolic tastes and odors has now been shown to be relatively simple, and the burden of responsibility for the greatest share of careful and continuous laboratory control may be delegated to the instrument known as the "Amperometric Residual Chlorine Recorder."

Acknowledgment

The author wishes to acknowledge the assistance given by the engineering staff of Wallace & Tiernan Co., Inc., during the installation and trial tests, particularly G. A. Campbell, John Peddieson and George Clark of the Newark office and W. E. Smith and John Perry of the Detroit office.

Reference

1. RUCHHOFT, C. C., & ETTINGER, M. B. Tastes and Odors in Water Resulting From Industrial Wastes. Inservice Training Course for Water Works Personnel. May 5-6, 1947. School of Public Health, Ann Arbor, Mich.

Tentative Regulations Governing Water Service

California Section Report

The California Section, at its meeting on October 27, 1950, received and approved the report of a special committee on "Regulations Governing Water Service." The resolution of adoption reads:

WHEREAS *a greater degree of uniformity than now exists among the regulations of the various water utilities is generally agreed to be desirable; and*

WHEREAS *the Chairman, after appropriate action by the Executive Committee of the California Section of the American Water Works Association, appointed a Committee to prepare Tentative Water Service Regulations; and*

WHEREAS *said Committee, with the assistance of the Executive Committee of the California Section of the American Water Works Association, has prepared and arranged for circulation of copies of said Tentative Water Service Regulations to members of the California Section; and*

WHEREAS *these Tentative Water Service Regulations have been discussed before members of the Association in Sacramento, Calif., on Oct. 27, 1949; in Santa Cruz, Calif., on Apr. 17, 1950; and further discussed before the members at a meeting in San Diego, Calif., on Oct. 25, 1950;*

NOW, THEREFORE, BE IT RESOLVED *that in order to provide for a greater degree of uniformity of regulations among the water utilities, these Tentative Water Service Regulations are reasonable and necessary; and*

BE IT FURTHER RESOLVED *that the California Section of the American Water Works Association adopt these Tentative Water Service Regulations as a pattern to be followed by California water utilities in the preparation of their regulations.*

The Committee charged with the task of preparing the text included:

William C. Welmon, Chairman, Secretary & Chief Accounting Officer, Southern California Water Co., Los Angeles.

Robert C. Kennedy, Chief Engr., East Bay Municipal Utility Dist., Oakland.

John C. Luthin, Supt., Water Dept., Santa Cruz.

Frederick Schafer, Administrative Aid, Long Beach Water Dept., Long Beach.

It will be noted that the report is intended to be a guide to California Water Utilities in preparation of a revision of water service regulations.

This material is published in the JOURNAL *for the information of all water works executives who may be concerned with revision of their present regulations.*

Sec. 1—Definition of Terms

Applicant: An individual or agency applying for water service.

Utility: The public utility or publicly owned utility named herein.

Customer: An individual or agency of record receiving water service from the utility.

Date of presentation: The date upon which a bill or notice is mailed or delivered personally to the customer.

Domestic service: Provision of water for household residential purposes, including water for sprinkling lawns, gardens and shrubbery; watering livestock; washing vehicles; and

other similar and customary purposes.

Fire protection service: Provision of water to premises for automatic fire protection.

Flat rate service: Provision of water in unmeasured quantities.

Commercial service: Provision of water to premises where the customer is engaged in trade.

Flat rate: A fixed periodic charge for an unmetered service.

Industrial service: Provision of water to a customer for use in manufacturing or processing activities.

Irrigation service: Provision of water for commercial agricultural, floracultural or horticultural use.

Main extensions: Extension of distribution pipelines, exclusive of service connections, beyond existing facilities.

Mains: Distribution pipelines located in streets, highways, public ways or private rights of way which are used to serve the general public.

Meter rate service: Provision of water in measured quantities.

Municipal or public use: Provision of water to a municipality or other public body.

Premises: The integral property or area, including improvements thereon, to which water service is or will be provided.

Public utilities commission: The California Public Utilities Commission.

Service connection: The pipe, valves and other facilities by means of which the utility conducts water from its distribution mains to and through the meter, or to the curb stop or shutoff valve on an unmetered service connection.

Tariff schedules: The entire body of effective rates, rentals, charges, and regulations, as set forth herein.

Tariff sheet: An individual sheet of rate schedules and regulations.

Temporary service: A service for circuses, bazaars, fairs, construction work, irrigation of vacant property, and similar uses, that because of their nature will not be used steadily or permanently.

Sec. 2—Service Area

The area in which service is or will be furnished by a utility may be described, for those under municipal ownership, as a political subdivision or the area extending to the "city boundary line," or the limits may be fixed by ordinance.

For a privately owned utility, the area covered by the "Certificate of Public Convenience and Necessity" issued by the Public Utilities Commission should be designated as the service area.

Sec. 3—Description of Service

A. Supply

The utility will exercise reasonable diligence and care to deliver a continuous and sufficient supply of water to the customer at a proper pressure, and to avoid any shortage or interruption in delivery.

B. Quantity

When furnished for human consumption, the utility will endeavor to supply a safe and potable water at all times.

C. Classes of service

All services installed by the utility will be classified as follows:

1. Residential
2. Commercial
3. Industrial
4. Irrigation

5. Municipal or public use
6. Fire protection.

D. Types of service

The types of service available from the utility are:

1. Flat rate.
2. Metered rate.
3. Seasonal or summer resort.
4. Temporary.

Sec. 4—Application for Service

A. Application

Each applicant for water service will be required to sign a form provided by the utility, setting forth:

1. The date and place of application.
2. The location of premises to be served.
3. The date on which the applicant will be ready for service.
4. Whether the premises have ever before been supplied by the utility.
5. The purpose for which the service is to be used.
6. The size of service.
7. The address to which bills are to be mailed or delivered.
8. Whether the applicant is an owner or tenant of, or agent for, the premises.
9. The rate schedule desired, if optional rates are in effect.
10. An agreement to abide by all regulations of the utility.
11. Such other information as the utility may reasonably request.

The application is merely a written request for service and does not bind the applicant to take service for any period of time longer than the one upon which the rates and minimum charges of the selected rate schedule are based; neither does it bind the utility to give service, except under reasonable conditions.

B. Individual Liability for Joint Service

Two or more parties who join to make application for service shall be jointly and individually liable and shall be sent single periodic bills.

C. Changes in Customer's Equipment

Customers making any material change in the size, character or extent of the equipment or operations utilizing water service, or whose change in operations results in a large increase in the use of water, shall immediately give the utility written notice of the nature of the change and, if necessary, amend their application.

Sec. 5—Special Contracts

Contracts, other than applications, may be required prior to service, under the following conditions:

1. When required by provisions contained in a filed rate schedule. The duration of the contract will be that specified in the schedule.
2. When construction of special extension facilities is necessary.
3. For temporary service.
4. For standby service or fire service.
5. For connections with other qualified utilities.

Sec. 6—Special Information Required

A. Contracts

Each contract for water service will contain the following provision:

"This contract shall at all times be subject to such changes or modifications by the Public Utilities Commission (or by the governing Board) as said Commission (or Board) may, from time to time, direct in the exercise of its jurisdiction."

B. Customers' Bills

On each bill for water service rendered by the utility to its customers will be printed in substance the regulation on discontinuance and restoration of service:

"If this bill is not paid within fifteen days after presentation, service may be discontinued. A cash deposit and a reconnection fee may be required to reestablish service."

C. Deposit Receipts

Each receipt for a cash deposit to establish or reestablish credit for service will contain the following statements:

"This deposit will be applied to unpaid balances if service has been discontinued by the utility because of nonpayment of bills and the full amount shall be reestablished before service will be resumed.

"This deposit, less the amount of any unpaid water bills, will be refunded, without interest, on discontinuance of service. After the deposit has been held for twelve consecutive months, provided service has been continuous and all bills for such service have been paid promptly, the deposit will be refunded without application."

Sec. 7—Credit Establishment

A. Establishment of Credit

Each applicant, before receiving metered service, may be required to establish his credit by either of the following methods:

1. A cash deposit to secure payment of his water bills as prescribed in the regulation on deposits.

2. Use of service for more than a year, during the last twelve months of which the customer paid all water bills promptly without disconnection for nonpayment.

B. Reestablishment of Credit

To reestablish his credit, a customer will be required to pay all back bills up to the time service was discontinued. He may be required to pay a reconnection charge and make a cash deposit as described in the regulation on deposits.

Sec. 8—Deposits

A. Establishment of Credit

1. *Metered service.* The amount required to establish credit for metered service shall equal twice the estimated average of the periodic bill, but shall not be less than $2.50.

2. *Flat rate service.* No deposit shall be required for flat rate service, except as is provided for temporary service.

B. Reestablish Credit

1. To reestablish credit, customers must deposit an amount equal to twice the estimated average of the periodic bill, but not less than $2.50.

C. Unpaid Accounts

Deposits prescribed herein may be applied to unpaid bills for water service when such service has been discontinued.

1. The utility may require the customer to redeposit a specified amount before rendering water service again.

D. Refund or Disposition of Deposits

This deposit, less the amount of any unpaid water bills, will be refunded, without interest, on discontinuance of service. After the deposit has been held for twelve consecutive months, provided service has been continuous

and all bills for such service have been paid promptly, the deposit will be refunded without application.

Sec. 9—Notices

A. Notices to Customers

Notices from the utility to a customer will normally be given in writing, and either delivered or mailed to him at his last known address.

Where conditions warrant and in emergencies, the utility may resort to notification either by telephone or messenger.

B. Notices From Customers

Notice from the customer to the utility may be given by him or his authorized representative orally or in writing [1] at the utility's operating office, [2] to an employee of the utility or [3] to an agent duly authorized to receive notices or complaints.

Sec. 10—Service Connections and Meters

A. Service Connections

The utility * will, at its own expense, furnish and install a service of such size and at such location as the applicant requests, provided such requests are reasonable; the service will be installed from its water distribution main to the curb line or property line of the premises which may abut on the street, on other thoroughfares, or on the utility right-of-way or easement.

The utility † will furnish and install a service of such size and at such location as the applicant requests, provided such requests are reasonable; the service will be installed from its water distribution main to the curb line or property line of the premises which may abut on the street, on other thoroughfares, or on the utility right-of-way or easement. Charges for new services are payable in advance and shall be as follows:

Size of Service	*Charge*
¾-in.	$....................
1-in.	....
1½-in.	....
2-in.	....

For services larger than 2 in. the applicant will be billed for the actual cost of installation exclusive of the meter.

Only duly authorized employees or agents of the utility will be permitted to install a service connection from the utility's main to the customer's premises.

B. Meters

1. Meters, when authorized, will be installed at the curb, at the property line, or in sidewalk basements, and shall be owned by the utility and installed and removed at its expense.

2. No rent or other charge will be paid by the utility for a meter or other facilities, including housing and connections, located on a customer's premises.

3. All meters will be sealed by the utility at the time of installation, and no seal shall be altered or broken except by one of its authorized employees or agents.

4. The utility reserves the right to meter any service and apply the established metered rates.

C. Change in Location of Meters or Services

Meters or services moved for the convenience of the customer will be relocated at the customer's expense.

* Applies only to privately owned utilities.
† Applies only to publicly owned utilities.

Meters or services moved to protect the utility's property will be moved at utility expense.

D. Changes in Size of Meter

Permanent changes in the size of meters on existing services will be made without charge to the customer. For each subsequent change in size made within any 18-month period the following charge will be made: For any change in size of $\frac{5}{8}$ in. up to and including 2 in. meters, the sum of $2.50 will be charged; for larger meters the actual cost will be charged.

E. Ownership

The service connection, whether located on public or private property, is the property of the utility, and the utility reserves the right to repair, replace and maintain it, as well as to remove it upon discontinuance of service.

F. Maintenance

The service connection, including the meter and the meter box, will be repaired and maintained by the utility at its expense, but the utility is not responsible for the installation and maintenance of water lines beyond the end of its service.

Sec. 11—Multiple Units

A. Number of Services to Separate Premises

Separate premises under single control or management will be supplied through individual service connections unless the utility elects otherwise.

B. Service to Multiple Units

Separate houses, buildings, living or business quarters on the same premises or on adjoining premises, under a single control or management, may be served at the option of the applicant by either of the following methods:

1. Through separate service connections to each or any unit provided that the pipeline system from each service is independent of the others, and is not interconnected.
2. Through a single service connection to the entire premises, on which only one minimum charge will be applied.

The responsibility for payment of charges for all water furnished to combined units, supplied through a single service connection, must be assumed by the applicant.

C. Resale of Water

Except by special agreement with the utility, no customer shall resell any of the water received by him from the utility, nor shall such water be delivered to premises other than those specified in his application for service.

Sec. 12—Bills and Payment

A. Rendering of Bills

1. *Meter Readings*

a. Meters will be read at regular intervals for the preparation of regular bills, and as required for the preparation of opening bills, closing bills and special bills.

b. It may not always be possible to read meters on the same day of each period. Should a monthly billing period contain less than 27 or more than 33 days, a pro-rata correction will be made. For bimonthly billing, if the period contains less than 54 or more than 66 days, a pro-rata correction will be made.

2. Bills for water service will be rendered monthly or bimonthly unless otherwise provided in the rate schedule.

3. *Flat Rate Service*

Bills for flat rate service are payable in advance. The opening bill for flat rate service will not be less than the estimated monthly charge for the service. The amount paid in excess of the prorated period will be credited against the charge for the succeeding month.

4. *Opening and Closing Bills*

a. Opening bills, closing bills, and monthly bills rendered for periods smaller or greater than normal will be prorated.

b. For metered service, if actual use is greater than the monthly minimum, the charge should be based on actual consumption.

c. If the total period of water service is less than one month, the bill will not be less than the monthly minimum charge.

B. Payment of Bills

1. Periodic bills are due and payable on presentation. Payment may be made at the utility's office or to an authorized collector.

2. Closing bills, if service is to be discontinued, are due and payable on presentation. Collection will be made at the time of presentation.

3. Fifteen days will be allowed after bills are mailed before service is discontinued for nonpayment.

4. When bills are delinquent, the utility may demand that the full amount of both delinquent and current bills be paid in full.

C. Billing of Separate Meters Not Combined

1. Each meter on customer's premises will be considered separately and the readings of two or more meters will not be combined unless specifically provided for in the rate schedule, or unless the utility's operating convenience requires the use of more than one meter, or of a battery of meters. The minimum monthly charge for such combined meters will be based on the diameter of the total combined discharge areas of the meters.

Sec. 13—Disputed Bills *

Should the customer dispute the correctness of a bill for utility water service and not pay it within 15 days after presentation, the utility will notify the customer in writing:

1. That in lieu of paying the disputed bill he may deposit with the California Public Utilities Commission the amount claimed due by the utility.

2. That checks or other forms of remittance so deposited should be made payable to the California Public Utilities Commission.

3. That upon receipt of a deposit, the commission will investigate the matter, advise both parties of its findings, and dispose of the deposit in accordance with its findings.

4. That service will not be discontinued pending the outcome of the commission's investigation provided that subsequent bills are paid or deposited with the commission.

5. The failure of the customer to make such deposits within ten days after the date of notification will warrant discontinuance of his service without further notice.

Sec. 14—Meter Error

A. Meter Test

1. Prior to installation, each meter will be tested and no meter found to register more than 2 per cent fast or

* Applies only to privately owned utilities.

slow under conditions of normal operation will be placed in service.

2. *On Customer Request.*

a. A customer may, giving not less than one week's notice, request the utility to test the meter serving his premises.

b. The utility may require the customer to deposit an amount to cover the reasonable cost of test, as follows:

Size of Meter	*Amount of Deposit*
1 in. or smaller	$2.50
Larger than 1 in.	$5.00

c. This deposit will be returned if the meter is found to register more than 2 per cent fast. The customer will be notified, not less than five days in advance, of the time and place of the test.

d. A customer shall have the right to require the utility to conduct the test in his presence, or in the presence of his representative.

e. A written report giving the results of the test will be shown to the customer within ten days after completion of the test.

B. Adjustment of Bills for Meter Error

1. *Fast Meters*

When, upon test, a meter is found to be registering more than 2 per cent fast, under conditions of normal operation, the utility will refund to the customer the full amount of the overcharge based on corrected meter readings for the period, not exceeding six months, that the meter was in use.

2. *Slow Meters*

a. When, upon test, a meter used for domestic or residential service is found to be registering more than 25 per cent slow, the utility may bill the customer for the amount of the undercharge based upon corrected meter readings for the period, not exceeding six months, that the meter was in use.

b. When, upon test, a meter used for other than domestic or residential service is found to be registering more than 5 per cent slow, the utility may bill the customer for the amount of the undercharge based upon correct meter readings for the period, not exceeding six months, that the meter was in use.

3. *Nonregistering Meters*

The utility may bill the customer for water consumed while the meter was not registering. The bill will be at the minimum monthly meter rate or will be computed upon an estimate of consumption based either upon the customer's prior use during the same season of the year or upon a reasonable comparison with the use of other customers receiving the same class of service during the same period and under similar circumstances and conditions.

Sec. 15—Discontinuance of Service

A. Nonpayment of Bills

1. A customer's water service may be discontinued if a bill is not paid within fifteen days after presentation. The service will not be discontinued, however, until the amount of the deposit made to establish credit for that service has been fully absorbed.

2. A customer's water service may be discontinued if water service furnished at a previous location is not paid for within fifteen days after presentation of a bill.

3. If a customer receives water service at more than one location and the bill for service at any one location is not paid within fifteen days after presentation, water service at all locations may be turned off. Domestic service,

however, will not be turned off for nonpayment of bills for other classes of service.

B. Unsafe Apparatus

1. The utility may refuse to furnish water and may discontinue service to any premises where apparatus, appliances or equipment using water is dangerous, unsafe or not in conformity with any laws or ordinances.

2. The utility does not assume liability for inspecting apparatus on the customer's property. The utility does reserve the right of inspection, however, if there is reason to believe that unsafe apparatus is in use.

C. Service Detrimental to Others

1. The utility may refuse to furnish water and may discontinue service to any premises where the demand is greatly in excess of past average or seasonal use, and where such excessive demands by one customer are or may be detrimental or injurious to the service furnished to other customers.

2. The utility may refuse to furnish water and may discontinue service to any premises where excessive demands by one customer will result in inadequate service to others.

D. Fraud and Abuse

The utility shall have the right to refuse or to discontinue water service to any premises to protect itself against fraud or abuse.

E. Noncompliance

The utility may, unless otherwise provided, discontinue water service to a customer for noncompliance with any of these regulations if the customer fails to comply with them within five days after receiving written notice of the utility's intention to discontinue service. If such noncompliance affects matters of health and safety, and conditions warrant, the utility may discontinue water service immediately.

F. Customer's Request for Service Discontinuance

1. A customer may have his water service discontinued by notifying the utility reasonably well in advance of the desired date of discontinuance. He will be required to pay all water charges until the date of such discontinuance.

2. If notice is not given, the customer will be required to pay for water service for two days after the utility has learned that the customer has vacated the premises or otherwise has discontinued service.

G. Restoration—Reconnection Charge

The utility may charge $2.00 for restoring water service which has been discontinued because of noncompliance with these rules.

Sec. 16—Automatic Fire Service

A. Purpose

An automatic fire service connection in 3- to 10-in. size will be furnished only if adequate provision is made to prevent the use of water from such services for purposes other than fire extinguishing.

B. Application and Agreement

The applicant will be required to sign a special application and agreement form that will be furnished upon request.

C. Installation Charges

The applicant will be required to make payment in advance of the estimated cost of installing the service connection and meter, or at its option

the utility may agree to install the connection and meter in accordance with the following schedule:

Size in.	*Charge per Connection*
3	$........
4	....
6	....
8	....
10	....

D. Quantitative Charges

1. *Water for fires.* No charge will be made for water used to extinguish accidental fires.

2. *Water for fire storage tanks.* Occasionally water may be obtained from a private fire service for filling a tank connected with the fire service, but only if written permission is secured from the utility in advance and an approved means of measurement is available. The rates for general use will be applied.

3. *Other.* Water lost through leakage or in testing or used in violation of the utility's regulations shall be paid for by the applicant at double the rate charged for general use.

E. Violation of Agreement

If water is used from a fire service in violation of the agreement or of these regulations, the utility may, at its option, discontinue and remove the service.

F. Ownership of Connection

The service connection and all equipment appurtenant thereto, including the meter, shall be the sole property of the utility, and no part of the cost thereof will be refunded to the applicant.

G. Pressure and Supply

The utility assumes no responsibility for loss or damage because of lack of water or pressure and merely agrees to furnish such quantities and pressures as are available in its general distribution system. The service is subject to shutdowns and variations required by the operation of the system.

Sec. 17—Temporary Service

A. Time Limit

Temporary service connections shall be disconnected and terminated within six months after installation unless an extension of time is granted in writing by the utility.

B. Charge for Water Served

Charges for water furnished through a temporary service connection shall be at the established rates for other customers.

C. Installation Charge and Deposits

The applicant for temporary service will be required:

1. To pay the utility, in advance, the estimated cost of installing and removing all facilities necessary to furnish such service, or, at the utility's option, if service is supplied through a fire hydrant, the applicant will be charged in accordance with the following rate schedule:

Flat charge per connection, for both installation and removal of service facilities, including the meter:	$......
Each additional move of facilities to another location:	$......

2. To deposit an amount sufficient to cover bills for water during the entire period such temporary service may be used, or to otherwise establish his credit.

3. To deposit with the utility an amount equal to the value of any equipment loaned by the utility to such applicant for use on temporary services.

D. Responsibility for Meters and Installation

The customer shall use all possible care to prevent damage to the meter or to any other loaned facilities of the utility which are involved in furnishing the temporary service from the time they are installed until they are removed, or until 48 hours' notice in writing has been given to the utility that the contractor or other person is through with the meter or meters and the installation. If the meter or other facilities are damaged, the cost of making repairs shall be paid by the customer.

E. Temporary Service on a Fire Hydrant

If temporary service is supplied through a fire hydrant, a permit for the use of the hydrant shall be obtained from the proper authority and the utility, unless the installation is of a type that does not preclude the use of the fire hydrant for the fighting of fires. It is specifically prohibited to operate the valve of any fire hydrant other than by the use of a spanner wrench designed for this purpose.

F. Unauthorized Use

Tampering with any fire hydrant for the unauthorized use of water therefrom, or for any other purpose, is a misdemeanor, punishable by law.

Sec. 18—Pools and Tanks

When an abnormally large quantity of water is desired for filling a swimming pool or for other purposes, arrangements must be made with the utility prior to taking such water.

Permission to take water in unusual quantities will be given only if it can be safely delivered through the utility's facilities and if other consumers are not inconvenienced.

Sec. 19—Fire Hydrants

A. Use of and Damage to Fire Hydrants

No person or persons, other than those designated and authorized by the proper authority, or by the utility, shall open any fire hydrant, attempt to draw water from it or in any manner damage or tamper with it. Any violation of this regulation will be prosecuted according to law.

B. Moving of Fire Hydrants

When a fire hydrant has been installed in the location specified by the proper authority, the utility has fulfilled its obligation. If a property owner or other party desires a change in the size, type or location of the hydrant, he shall bear all costs of such changes, without refund. Any change in the location of a fire hydrant must be approved by the proper authority.

Sec. 20—Responsibility for Equipment

The customer shall, at his own risk and expense, furnish, install and keep in good and safe condition all equipment that may be required for receiving, controlling, applying and utilizing water, and the utility shall not be responsible for any loss or damage caused by the improper installation of such water equipment, or the negligence, want of proper care or wrongful act of the customer or of any of his tenants, agents, employees, contractors, licensees or permittees in installing, maintaining, using, operating or interfering with such equipment. The utility shall not be responsible for damage to property caused by spigots, faucets, valves and other equipment

that are open when water is turned on at the meter, either when the water is turned on originally or when turned on after a temporary shutdown.

Sec. 21—Damage to Utility's Property

The customer shall be liable for any damage to a meter or other equipment or property owned by the utility which is caused by an act of the customer or his tenants, agents, employees, contractors, licensees or permittees, including the breaking or destruction of locks by the customer or others on or near a meter, and any damage to a meter that may result from hot water or steam from a boiler or heater on the customer's premises. The utility shall be reimbursed by the customer for any such damage promptly on presentation of a bill.

Sec. 22—Control Valves

The customer shall install a suitable valve, as close to the meter location as practicable, the operation of which will control the entire water supply from the service.

The operation by the customer of the curb stop in the meter box is not permitted.

Sec. 23—Cross Connections

A. Health Regulations

Regulations of the California State Department of Public Health and the Drinking Water Standards of the United States Public Health Service prohibit unprotected cross connections between the public water supply and any unapproved source of water.

B. Utility Requirements

To comply with the regulations of these health agencies, the utility will require the installation of approved double check valves or other approved backflow protection devices by and at the expense of the customer before service will be granted under any of the following conditions:

1. Where an unapproved fresh water supply is already available from a well, spring, reservoir or other source. If the customer agrees to abandon this other supply and agrees to remove all pumps and piping necessary for the utilization of this supply, the installation of backflow protective devices will not be required.
2. Where salt water, or water otherwise polluted, is available for industrial or fire protection purposes, or where fresh water hydrants are or may be installed on piers or docks.
3. Where the premises are or may be engaged in industrial processes using or producing process waters or liquid industrial wastes, or where the premises are or may be engaged in handling sewage or any other dangerous substance.
4. Where the circumstances are such that there is special danger of backflow of sewage or other contaminated liquids through plumbing fixtures or water-using or treating equipment, or storage tanks and reservoirs.
5. Where an approved water supply line terminates as a pier head outlet which is used to supply vessels at piers or waterfronts. These installations shall be located where they will prevent the return of any water from a vessel or any other source into the approved water supply line.

C. Plumbing Changes Required

In special circumstances, when the customer is engaged in the handling of especially dangerous or corrosive liquids or industrial or process waters, the utility may require the customer to

eliminate certain plumbing or piping connections as an additional precaution and as a protection to the backflow preventive devices. In making plumbing connections the customer shall be guided entirely by local or state planning ordinances and not by the utility.

D. Relief Valve Required

As a protection to the customer's plumbing system, a suitable pressure relief valve must be installed and maintained by him, at his expense, when check valves or other protective devices are used. The relief valve shall be installed between the check valves and the water heater.

E. Backflow Protection on Additional Water Supply Lines

Whenever backflow protection has been found necessary on a water supply line entering a customer's premises, then any and all water supply lines from the utility's mains entering such premises, buildings or structures shall be protected by an approved backflow device, regardless of the use of the additional water supply lines.

F. Protection Against Interstreet Main Flow

Two or more services supplying water from different street mains to the same building structure or premises through which an interstreet main flow may occur, shall have a standard check valve on each water service to be located adjacent to and on the property side of the respective meters.

Such check valves shall not be considered adequate if backflow protection is deemed necessary to protect the utility's mains from pollution or contamination, but the installation of approved dual backflow devices at such meters shall take the place of, and satisfy the requirement for, standard check valves.

G. Inspection of Backflow Protective Devices

The double check valve or other approved backflow protection devices may be inspected and tested periodically for water tightness by the utility.

In addition, the regulations of the State Department of Public Health require that the owner of any premises on which or on account of which check valves or other protective devices are installed, shall inspect these devices for water tightness and reliability at least every three months. The devices shall be serviced, overhauled, or replaced whenever they are found defective and all costs of repair and maintenance shall be borne by the customer.

H. Discontinuance of Service for Defective Apparatus

The service of water to any premises may be immediately discontinued by the utility if any defect is found in the check valve installations or other protective devices, or if it is found that dangerous unprotected cross connections exist. Service will not be restored until such defects are corrected.

Sec. 24—Ground-Wire Attachments

All individuals or business organizations are forbidden to attach any groundwire or wires to any plumbing which is or may be connected to a service connection or main belonging to the utility; the utility will hold the customer liable for any damage to its property occasioned by such groundwire attachments.

Sec. 25—Water Waste

Where water is wastefully or negligently used on a customer's premises,

seriously affecting the general service, the utility may discontinue the service if such conditions are not corrected within five days after giving the customer written notice.

Sec. 26—Access to Premises

A. The utility or its duly authorized agents shall at all reasonable times have the right to enter or leave the customer's premises for any purpose properly connected with the service of water to the customer.

B. Any inspection or recommendations made by the utility or its agents on plumbing or appliances or use of water on the customer's premises, either as the result of a complaint or otherwise, will be made or offered without charge.

Sec. 27—Interruptions in Service

The utility shall not be liable for damage resulting from an interruption in service. Temporary shutdowns may be resorted to by the utility for improvements and repairs. Whenever possible, and as time permits, all customers affected will be notified prior to such shutdowns.

The utility will not be liable for interruption, shortage or insufficiency of supply, or for any loss or damage occasioned thereby, if caused by accident, act of God, fire, strikes, riots, war or any other cause not within its control. The utility, whenever it shall find it necessary or convenient for the purpose of making repairs or improvements to its system, shall have the right temporarily to suspend delivery of water and it shall not be liable for any loss or damage occasioned thereby. Repairs or improvements will be prosecuted as rapidly as is practicable and, so far as possible, at such times as will cause the least inconvenience to the customers.

Financing Water Works Improvements

By W. L. Gilmer

A paper presented on October 12, 1950, at the Alabama-Mississippi Section Meeting, Mobile, Ala., by W. L. Gilmer, Partner, Polglaze and Basenberg, Engrs., Birmingham, Ala.

BECAUSE the urban population of Alabama and Mississippi has grown rapidly during the past ten years, a great demand for extensions of existing public water systems as well as for new systems in towns without public water supplies has been created. Preliminary population data recently released by the U.S. Bureau of the Census indicate that, although Mississippi as a whole has undergone a slight decrease in population, nearly all cities and towns in both Mississippi and Alabama have grown substantially. It may be seen from Table 1 that more than 80 per cent of the towns in these states have experienced a population growth of 5 per cent or more in the past decade.

Most of the cities and towns have also become more industrialized with consequent demands on the local water systems to supply large quantities of water for the new and enlarged industries. This increased demand for water, coupled with higher construction costs, has created a difficult problem for numerous operators of water systems.

In the past, improvements to municipal systems were usually paid for with cash on hand or were financed by general obligation bonds or warrants. This method of financing is no longer practicable for many cities in which water department surpluses and reserves have been used to help meet the rising costs of other municipal services. It is true that revenues from taxes, licenses and other sources have increased during the past ten years and that the gross revenue of the water system has also increased. Operating costs, however, have risen to such an extent that available funds have not usually kept pace with demands for service, particularly nonrevenue-producing services. As a result, the governing bodies have quite often bled the water systems to provide revenue for other municipal functions.

Many cities and towns have found that, although additions to their water systems were required, hospitals, schools, roads and other municipal improvements were also needed, and, as most of these projects produce no revenue, they are financed with general obligation bonds and warrants, leaving water works improvements to be financed entirely from water revenues.

During the war years, very few water systems undertook major construction or improvements. Since 1945, therefore, a number of cities in Alabama and Mississippi have found themselves faced with the problem of re-

habilitating existing plants, replacing worn and obsolete equipment, and making other delayed additions and improvements. This problem was intensified by the need for added service required for new homes, housing projects, industries and commercial establishments. Often the situation was so acute that merely providing a safe potable water for domestic consumption became a problem. To complicate matters further, a home building boom developed, and fire protection was required for large numbers of new houses built in outlying, undeveloped areas. Materials and labor were scarce,

TABLE 1
Population Change in Towns and Cities

	Alabama	Mississippi
Up more than 5 per cent	119	96
Less than 5 per cent change	12	15
Down more than 5 per cent	10	6
TOTAL LISTED	141	117

but, given sufficient time and adequate funds, the cities could have managed to find enough of both. Nearly all municipally owned water systems, however, suffered from a shortage of available funds. Obtaining labor and materials in the fastest possible time, and arranging for a satisfactory method of financing became their chief concern.

This was the predicament of established municipally owned water systems. Several incorporated towns in Alabama and Mississippi did not have a water system in 1946, but as they too began to grow, the desire arose for a public water system and other municipal services. Certain of these towns had cash reserves on hand which could be applied toward construction, but costs were so high that usually the cash would pay for only a small part of the system. These towns also found that their property valuation was low and the legal debt limit established by state law was so low that general obligation bonds or warrants added to the cash on hand would seldom completely pay for the water system. Certain towns financed construction of new water systems with water revenue bonds, in addition to general obligation bonds and cash on hand; in others, second mortgages were bought by residents of the towns.

Water Revenue Bonds

As a result of the conditions described, nearly all construction of new systems, and improvements and additions to existing systems, have been financed with water revenue bonds or warrants in the past few years. This method of financing is largely dependent upon anticipated gross revenue, operating expenses and net revenues. The logical person to forecast prospective revenues and operating expenses is the engineer, and he therefore plays a more important part in the financing of water works construction now than at any time in the past twenty or thirty years. Water revenue bonds to be saleable must be backed by an engineering report describing the city, the water system, water consumption, operating costs, rate structure, expected gross revenues and net revenues.

A water works system must, of course, be designed to serve not only the present but also the future needs of a community. This principle is of great importance in smaller cities because water revenue bonds usually mature

over a period of twenty to thirty years and the smaller cities, for the most part, sell what is known as a "closed end issue." These bonds usually have a call feature, but they must be called from water revenues. Water revenue bonds or warrants ordinarily provide that all principal and interest payments on the issue will be paid from water revenues only; in addition, the system is mortgaged to the bond holder. Several provisions included in the indenture pertaining to revenues, to operation of the system and to revenue funds, are listed below:

1. The issuing authority must at all times charge a rate sufficient to enable the system to pay all operating costs and meet all principal and interest payments.
2. Water revenues must first be used to pay operating costs.
3. All principal and interest payments on the debt must be paid when due.
4. Cushion or reserve funds and extention and maintenance funds should be established and added to.
5. Surplus funds may be used by the city for other purposes.

These provisions often mean that, with a closed issue and bonds called solely from revenue, additional improvements needed before the bonds outstanding are retired must be financed by revenue bonds issued on a second mortgage.

Second Mortgages

Larger cities, with proven records of operation, do not have much difficulty selling second mortgage paper, provided the net revenue is sufficient, not only to pay operating charges and amortize the old and new debt, but also to provide a reasonable surplus. In general these cities have found it necessary to maintain a coverage at least 150 per cent above all debt requirements; that is, net revenue must be at least 1.5 times the amount required for debt service. Desirable coverage would be 1.75 to 2.0 times debt service; with this amount of coverage, money can usually be borrowed at a reasonable interest rate. Two Alabama cities recently issued second mortgage papers which brought a lower interest rate than their first mortgage; this due, in part, to cheaper money but also to the fact that, although the original coverage was 1.5, the coverage for both old and new debt, when the second mortgage paper was issued, amounted to approximately 2.3.

Some of the smaller cities, however, have found it almost impossible to sell second mortgage paper; those which have been successful in selling it have usually paid considerably higher interest rates. In order to avoid issuing second mortgage paper, the engineer will usually attempt to design a water system of sufficient capacity to serve the city throughout the life of the original bonds; and estimates of future population and water needs must, therefore be made.

Population Studies

In making such estimates, the engineer will study the past growth of the city and the growth of larger cities with similar agricultural, commercial and industrial activities, and similar facilities for education and transportation. He will try to take all conditions into account which might retard or accelerate growth, and will, on this basis, make an estimate of population 20 or 30 years hence. The estimate must be conservative from a revenue-producing

standpoint or prospective bond buyers will distrust the entire report. It cannot be too conservative, however, or the plant may prove inadequate before all bonds have been retired.

Using his projected population figures, the engineer will estimate probable water usage. Only then can the size of the plant be determined, a preliminary estimate of cost be prepared and designs of improvements begun. Once the cost of the project has been approximated, it is possible to determine whether sufficient revenue will be available to finance the project. Records of operation and revenue of an existing system which is being enlarged or improved may be referred to for information on the quantity of water pumped and sold, pumping costs, chemical costs and salaries. The engineer will determine from these factors whether or not the system is being operated on a sound and efficient basis. Frequently, an exhaustive study of unaccounted-for water is necessary, and recommendations are made to help control excessive amounts.

Excessive quantities of unaccounted-for water may not only hinder the financing of contemplated improvements, but may also result in improvements or enlargements being undertaken before they are actually needed. The author knows of several cities which, by reducing unaccounted-for water, were able either to delay enlargement of plant facilities several years, or else materially to reduce the magnitude of the enlargement program. The reduction of unaccounted-for water enabled certain other cities in their reports to prospective bond buyers to present a more favorable picture of the system, with capable management and increased coverage of the proposed debt service requirements as attractive features.

An examination of past records sometimes indicates that "book" operating costs are very high, whereas actual costs are at least reasonable. The discrepancy is often caused by the failure of management to capitalize on all permanent improvements, such as meters, services or short extensions of small mains. Some systems charge small capital improvements to operating expenses; if these improvements were capitalized, some operating costs would be reduced 30–50 per cent and net revenue would be increased appreciably, with a subsequent increase in coverage of the proposed debt.

When unaccounted-for water, operating costs, and capital improvements have been studied, the gross revenue and net revenue may be examined.

Revenues

Because of the marked increase in construction costs during the past five years, it is seldom possible to finance construction of improvements from current gross revenues. Gross revenues have increased during the period, but, in general, the increase has been due to more customers and greater use of water rather than to rate increases. With the added burden of greater use, operating expenses have increased at a much faster pace than have revenues. Net revenue, at best, is only slightly greater than in 1945 and 1946.

The *Engineering News-Record* Construction Cost Index is generally accepted as authoritative in the field. This index was 308 in 1945 and approximately 535 in October 1950, indicating that construction costs have increased approximately 73 per cent

during the past five years. As the plant size necessary to serve 1,000 people has not changed in the same interval, however, it must be calculated that approximately 73 per cent more money is now needed per 1,000 consumers than was needed in 1945. Since net revenues have increased very little during this period, a rate increase is usually needed when water works improvements are undertaken.

Water Rate Increases

Increasing water rates presents problems to both the municipally operated system and the privately owned utility. In Alabama, a private utility must file application for a rate increase with the Public Service Commission, submitting evidence to justify the increase. A municipally operated system, on the other hand, does not come under the jurisdiction of the commission and its rate increases are subject only to the discretion of the municipality's officials. Proposals to increase water rates are not generally well received by city officials for, although they may realize the need for improvements and the consequent need of increased water rates, they must also consider the political results of an increase. Most municipal governments have found that, by presenting the problem to the people and explaining the need for improvements and rate increases, opposition can be held to a minimum.

For example, an Alabama city of approximately 20,000 people recently increased all minimum rates—some by as much as 100 per cent—with very little objection from the majority of its citizens. The aid of the local newspaper and of civic organizations had been enlisted in presenting the problem to the citizens before the rates were increased; thus, when the new rates were put into effect, most people were fully informed of the need for the increase and did not object to it.

Alabama state law permits the municipality or a municipally owned water works board to issue water revenue bonds or warrants without an election. Cities in Mississippi, however, are required to hold an election before any bonds may be issued. The matter of rate increases must therefore be handled properly or the bond issue may be defeated at the polls. When one of Mississippi's largest cities needed a rate increase recently, good publicity and active work on the part of the city council and civic organizations made possible the approval of the bond issue by a substantial majority at the polls.

As previously discussed, construction costs have increased approximately 73 per cent since 1945 and 150 per cent since 1935. The cost of living index for the nation, according to the Bureau of Labor Statistics, has risen from 98.1 in 1935 to 176 in July, 1950. At the same time, annual per capita income has increased in Alabama from \$213 in 1935 to \$849 in 1949; in Mississippi, the increase was from \$177 to \$720. It is readily apparent that although the cost of living has increased slightly more than 76 per cent in the past 15 years, annual per capita income in both states has nearly quadrupled. The cost of water to an average family in the state of Mississippi or Alabama ranges from \$1.75 to \$2.00 per month, and usually this cost has not changed since 1935. Because it is a minor constituent of the cost of living, an increase of even 100 per cent in the price of water would have a negligible effect. Per capita income has increased to such an extent that

doubling family expenditures for water would not be disproportionate.

Rate Schedules

Water sales and charges for fire protection constitute the major sources of revenue of the average water works system in Alabama and Mississippi. The practice in the past has been to maintain a schedule of rates covering both minimum charges and water usage charges. The purpose of the minimum charge was to insure the water department a fair return on plant investment. Minimum meter charges have been compared to a demand charge although interpretation of their significance has led to some controversy. It is quite true that water meters presently in use are not demand meters. In the absence of a demand meter of reasonable cost, however, the monthly minimum charge appears to be the most logical method of insuring a fair return on investment.

More and more cities have come to agree that a graduated scale of monthly minimum meter charges should be a part of the rate schedule. Large users of water have, for the past several years, generally used considerably more water than the amount covered by the minimum charge and therefore it has seldom worked a hardship on anyone. On the other hand, it has protected the city's investment and has made water revenue bonds more attractive to the prospective bond buyer.

A reasonable minimum charge is essential to a new system in a small town or for enlargements to an existing system. The minimum charge usually permits a customer to use approximately 3,000–4,000 gal. of water per month. Water customers in the larger cities may be classified as follows: [1] approximately 25–35 per cent use only the minimum amount of water each month, [2] 50 per cent use 4,000–15,000 gal. per month and [3] the balance use more than 15,000 gal. per month. An engineer can examine the records of a water works, to determine the proportion of customers in each category and prepare a table of anticipated revenues. Generally, in the smaller cities, very few customers use more than the minimum amount of water. As the engineer's estimate of anticipated revenue must be conservative, he will usually prepare a schedule of anticipated revenue which credits nearly all customers with minimum water use. Given a reasonable minimum charge, therefore, the prospective bond purchaser is assured of sufficient revenue to operate the system and amortize the debt; if a minimum charge were not made, it would be entirely possible that principal payment would be in default within a short time.

Water usage charges are an integral part of the water rate schedule. These charges are theoretically based on costs per 1,000 gal. of water, plus a fair profit. The cost of water includes operating costs, investment for capital expenditures, taxes and depreciation. In addition, the charge for water should provide sufficient revenue for normal extensions of the system. Fixed charges on work done in the past have remained unchanged, but all other costs, with the exception of electric power in some areas, have increased considerably. Schedules of water rates are usually calculated on a sliding scale; therefore, although the revenue received from small users is greater than the cost of producing and delivering the

water, the net revenue has decreased considerably. Operating costs have increased to such an extent that in many cities water is now being sold to large consumers at below cost. The margin of sales profit to large consumers has been held low to attract new industries to the states. The cost of water in most industries, however, is such a small part of total production cost, that where it has been found necessary to increase water rates, the industrial users have seldom objected.

Fire Protection Charges

Charges for private fire protection systems have long been made by water departments, but only recently have charges been set up for public fire protection. Owners of rental units or buildings are quite often charged only for their own water use and yet receive a valuable service from the water department for which no charge is made unless public fire protection is given weight in the rate structure, as a service which is expected from a municipality. General funds are used to pay for fire fighting equipment, firemen's salaries and alarm systems. It is only logical, therefore, that an increasing number of cities have begun to pay a fire hydrant rental to the water department, charging it against the general fund. When this is done, however, city officials generally contend that the water department should pay a tax equivalent on its property. Quite often this is merely a matter of bookkeeping, as the tax equivalent may offset the fire hydrant rental charge. It does, however, tend to separate a revenue-producing department from other city departments and discourages the diversion of water works funds to other municipal uses.

Bond Issue

The engineer, having completed his estimates of construction costs, rate study and projected earnings of the system, will prepare an amortization schedule—a purely mechanical task—for the proposed bond issue. The city can then prepare a bond issue. A recognized bond attorney must assist in preparing the issue and offer an opinion that the issue is a legal debt of the issuing body. The bonds are then ready for sale.

In Alabama, cities will often retain a fiscal agent, usually an experienced bond broker, to assist in advertising the issue and setting up the necessary covenants for depreciation, replacement funds and other matters. The fiscal agent plays an important part in presenting the issue to prospective buyers. Although one city recently retained a fiscal agent for this purpose, Mississippi law opposes their use. When a city cannot or will not retain a fiscal agent, the bond issue and the engineer's report are reviewed by a bond rating bureau which grades the bonds and circularizes prospective buyers and bond houses. An attorney's opinion of the bonds and the engineer's report are very important under such circumstances, because of the weight given to them by investors.

If a satisfactory proposal is received by the date set for receiving bids on the bonds, the city accepts it and the water works improvement program has been financed. This step completes the usual financing procedure. Some cities however, have found it necessary to finance improvements even though there were bonds outstanding which constituted first and, sometimes, second mortgages on the water system. These cities

sometimes retain a fiscal agent and arrange to sell the new issue to owners of the outstanding bonds at a reasonable rate. Arrangements have occasionally been made to issue a new first mortgage to cover both the outstanding issue and the cost of proposed improvements. The holder of outstanding bonds could thus trade his old bonds for a portion of the new issue.

Discussion

Donald Mills

Consulting Engineer, Selma, Ala.

Rising costs of materials have made it more difficult to finance small systems successfully. Larger cities wishing to finance improvements are able to show records of past earnings from which future income can be estimated. Small towns without water works, on the other hand, have no past earning records, and security must, therefore, be higher.

It should clearly be understood that only the rudiments of a system can be furnished at first—a water supply, elevated storage, fire protection in business sections and small mains to serve residential areas.

In general, a well supply must be used whenever possible to reduce capital cost. Every effort should be made not to compromise quality, particularly as it affects the size of tanks and mains in the heart of the system.

In Mississippi and Florida, a combination of general obligation and revenue bonds may be used to finance construction, whereas in Alabama, the general practice is to use only revenue bonds. A combination of general obligation and revenue bonds has the advantage of reducing the amount of revenue bonds, but, when used, all taxpayers, regardless of location, demand water service, and perhaps rightfully.

It is necessary for revenues to be as high as possible and operating expenses to be kept to a minimum to increase the net revenue available for debt service. Coverage of principal and interest may range between 1.60 and 1.75 (revenue from 1.60 to 1.75 times the debt service). Rates must be as high as possible without arousing customer resistance. A monthly minimum of $2.50 for 3,000 gal. is a good approximation. Operating costs should be kept to about $10.00 per customer per year.

Costs may be spread over a 30-year period to reduce the amount of principal and interest during the first few years. If it is not possible to obtain a debt coverage of 1.75 to sell bonds privately, the RFC will finance construction with 1.25 coverage, although current applications will probably not be filled unless construction is vital to the rearmament program.

Customer lists and deposits must be obtained to substantiate estimated revenues. Regulations must provide penalties and cut-offs for delinquency, which cannot be permitted.

All water should be metered wherever possible; no customers should be permitted to receive water without charge.

The cost of construction of the Chatom Water Works system was $90,000, of which $5,000 was contributed by the school board to reduce its fire insurance costs, leaving a balance of $85,000 still to be raised. At the start of operations 110 customers were

anticipated, with a minimum monthly charge of $3.00 per customer.

A large contribution was needed from the town's general fund to show even a small debt coverage. For this amount of revenue bonds, this could be accomplished only by transferring funds in the form of fire hydrant rentals. As the maximum rental permissible is $60, and $2,400 was needed, a total of 40 hydrants was necessary to produce this revenue. Sixteen fire hydrants were already located on 6- and 8-in. mains; 24 more were therefore needed. As placing this additional number on the larger mains would mean spacing them only 300 ft. apart, the problem was solved by installing 2-in. fire hydrants on 2-in. mains and charging $60 rental for all sizes.

The town is now operating the system successfully and is able to put a small sum in a cushion fund each month after meeting debt obligations.

Erratum

Because of an omission in the original report, an incomplete list of committee personnel accompanied the publication in the January 1951 JOURNAL (Vol. 43, p. 30) of excerpts from the Engineers Joint Council report on domestic and industrial aspects of "National Water Policy." Linn H. Enslow, Editor, *Water and Sewage Works*, New York, N.Y., should have been included as a contact member of the committee.

Factors Influencing the Efficiency of Activated Carbon

By D. Colebaugh, J. Filicky and A. Hyndshaw

A paper presented on September 7, 1950, at the Virginia Section Meeting, Richmond, Va., by A. Hyndshaw, Research Chemist, West Virginia Pulp & Paper Co., New York, N.Y.

POWDERED activated carbon was first used in 1930 to control disagreeable tastes and odors in public water supplies by George Spalding of the Hackensack Water Co. at New Milford, N.J. Since then, its use has steadily increased until approximately 1,300 plants now employ it to control tastes and odors.

The process by which activated carbon removes the taste and odor bodies is known as adsorption. Our knowledge of the actual nature of adsorption is limited, although there has been evidence that the process may be physical, chemical, electrical or a combination of all three. Practical operators are not so much concerned with the nature of adsorption, of course, as with the benefits derived from its action. Of primary interest to water works operators, therefore, is the action of activated carbon in eliminating tastes and odors in water.

Numerous factors affect the efficiency of carbon in adsorption. Some of these are not within the control of the water works operator; others, however, can be controlled. For example, the action of carbon is influenced by the duration of the contact period and the nature of the other chemical treatment. The latter influence is of particular interest to the water works operator because the chemicals used for disinfection or softening will often produce changes in the taste- and odor-bearing substance. Methods of solving this type of problem can best be explained by describing actual experiences.

Influence of pH

The efficiency of adsorption by activated carbon is influenced by the pH value of the water. In one midwestern city, decreased adsorption was noted at a high pH. During a taste and odor survey conducted at this plant, unsuccessful attempts were made to prepare odor-free water by passing tap water through a granular carbon filter. Only by reducing the pH of the tap water from 10.5 to 7.5 was the preparation of odor-free water by this method possible.

Special attention is usually required when carbon is applied at plants which use lime for softening or pH adjustment. Frequently a change in the order of adding chemicals is advantageous. At one plant in Minnesota, 75 lb. per mil.gal. (9 ppm.) of activated carbon removed only 10 per cent of the odor when the pH was 10.6, whereas the addition of carbon before

the lime resulted in a 70 per cent reduction.

Certain compounds, such as phenols, are less adsorbable at pH values above 8. An explanation for the decreased adsorption may lie in the fact that alkali converts the phenol to phenolate, the degree of conversion being proportional to the increase in pH. Because the salt of phenol is difficult to adsorb, decreased adsorption usually follows an increase in the formation of sodium phenolate.

A few compounds, such as aniline or pyridine, are much more readily adsorbed at high than at low pH values, but these compounds are rarely found in water supplies.

It should be mentioned, however, that in numerous water supplies, pH has less influence than in the situations described above.

Contact Time

Adsorption normally occurs as soon as carbon establishes contact with the taste and odor bodies. In a water plant where carbon dosage is relatively small, longer contact periods are desirable. Thus, in one midwestern city, satisfactory adsorption of taste and odor bodies by carbon was obtained by increasing the contact time from 15 to 30 minutes. At this plant, also, a decreased efficiency of carbon, caused by high pH of the water (10.5), was overcome by increasing the time of contact.

Chlorine

It is an almost universal practice to employ chlorine in some form or other for disinfection of raw water. Many plants, however, also use chlorine to control taste and odor, with varying degrees of success. Some plants have obtained decided improvement with the use of chlorine, whereas others have not. A number of plants using superchlorination, free residual chlorination, or marginal chlorination for taste and odor control employ supplementary treatment with carbon to produce a water acceptable to the public. In 1946, during an outbreak of *Asterionella* in an Ohio water plant, free residual chlorination reduced odor 40 per cent, but changed the characteristic taste of the water and made it unpalatable. It was necessary to supplement the treatment with carbon to reduce the concentration of odors in the water to a satisfactory level.

On occasion it has been advisable to change from free residual to marginal chlorination to prevent the formation of chlorinated compounds which were more unpleasant than those in the raw water. Thus, in one city in Illinois in 1948, a change from free residual to marginal chlorination was effective in producing a final product which was acceptable to the public. One city in Louisiana found that free residual chlorination changed the characteristic grassy odor of the water to a woody odor without changing its intensity.

At times free residual chlorination has intensified odors. Threshold odor tests conducted in a large midwestern city in 1947 revealed that increased concentrations of odors were caused by the formation of chlorinated compounds. Further studies indicated that each pound of free chlorine residual per million gallons (0.12 ppm.) increased the threshold odor value 2 units above that of unchlorinated water.

Other effects of carbon in combination with chemicals used for disinfecting water require consideration. For example, chlorine and carbon have an affinity for each other; the chlorine

adsorbed by the carbon is converted to a chloride by catalysis. It has been reported that carbon can adsorb 10 per cent of its weight of chlorine and still remain effective for adsorbing taste and odors. The decreased efficiency of carbon which would result from applying the two chemicals together is insignificant, but the oxidation potential of the chlorine would be destroyed. For this reason the point of application must be carefully chosen to prevent any possible interferences between the two chemicals.

It is frequently desirable for the water works operator to apply carbon after free residual chlorination, thus enabling the chlorine to effect some odor improvement and to reduce the amount of carbon required to produce a palatable water. This method was applied successfully in one city in Ohio in 1947, during an algae outbreak. Free residual chlorination followed by carbon was found to be more effective in removing taste and odors than either treatment used separately.

By contrast, a city in Texas in 1948 found chlorination detrimental to the action of carbon which was added later. The characteristic odor of the raw water was changed to an odor more difficult to adsorb than the original. Better results at this plant were obtained by adding carbon before chlorination.

Chloramines

The addition of ammonia to water, prior to treatment with chlorine, often prevents the formation of malodorous compounds resulting from the action of the chlorine on taste and odor compounds.

Three types of chloramines may be present in water—mono- and dichloramine and nitrogen trichloride. Of the three, monochloramine is considered least adsorbable by carbon.

Coagulation

Because of the proximity of the standby feed equipment and pipelines, the mixing basin is generally considered the most convenient point for applying carbon. Several advantages may be realized at this point of application:

1. The carbon can act as a nucleus upon which floc particles may form.
2. Sludge is stabilized.
3. Caking of sludge can be prevented, permitting the sludge to be hosed to the sewer.

In a city in Massachusetts in 1949, floc formation was found to interfere with the action of the carbon. The floc was so heavy that the carbon was immediately taken up and the adsorption of the taste and odor bodies was greatly reduced. Adjusting the floc formation to allow a longer period of contact resulted in a 90 per cent increase of the amount of odor removed.

Filters

Much has been said about the merits of carbon application to the tops of the filters. There are two primary objections, however, to this point of application. The first is that the filter runs are shortened, although filters kept in good condition are not appreciably affected. One large city in the midwest has applied as much as 350 lb. per mil.gal. (42 ppm.) directly upon the filters without having carbon pass through the filters or shortening the filter runs. Application of carbon to the tops of the filters actually accelerated the filtering rate.

The other objection is that carbon may pass through the filters. If car-

bon does pass through, it can be readily detected by its characteristic black color. When this happens, there is a good chance that other substances, not so easily detectable, are also passing through; thus carbon frequently acts as an indicator of other impurities. To correct such conditions, it is necessary to check other operations in the plant. In one city the trouble was found to be caused by a weir which was breaking up the floc; as a result, alum as well as carbon was passing through the filter. At a Minnesota plant, the coal particles used for filtering were found to be too large for proper filtration. Inspection of the filter effluent revealed the presence of alum floc as well as carbon.

Chlorine Dioxide

Quite recently chlorine dioxide was applied to the waters of clear wells for the elimination of medicinal tastes and odors. In one city in New York, where chlorine dioxide was tried for the disinfection of the water, it was applied in the settling basin. If chlorine dioxide is to be used for disinfection, selection of the point of carbon application will probably be influenced as it is with chlorine. The use of chlorine dioxide as a taste and odor control agent may be best illustrated by citing several plant studies.

Medicinal tastes and odors are sometimes present in the raw water of one plant in Kentucky. Plant studies conducted in 1948 indicated that chlorine dioxide used on a cost basis was more efficient than activated carbon in removing this taste and odor. With algae tastes and odors, however, the chlorine dioxide had little or no effect, and for these, activated carbon had to be relied on to produce a palatable water.

Tests made in 1949 at a plant in Wisconsin indicated that chlorine dioxide applied to the clear well did not effect any reduction in the algae tastes and odors, but acted rather as a specific for phenol contamination, which is encountered during the winter months.

Similar studies at a plant in Minnesota indicated that supplementary chlorine dioxide (0.6 to 1.2 ppm. sodium chlorite) applied to the clear well did not extend the odor reduction beyond the point already reached with activated carbon. Applying the chlorine dioxide to the raw water only decreased the raw water odor (swampy type odor) from threshold odor 14 to an average threshold odor of 12. Generally, the threshold odor number of the tap water should be 5 or less for the water to be considered palatable.

Handling Activated Carbon

Activated carbons used for water purification are delivered in a very finely divided state, the greater part passing a 325-mesh screen. This extreme fineness, combined with the apparently low density of the carbon, results in dusting and wetting characteristics which can be quite troublesome if preventive measures are not taken.

Although some dusting usually occurs during unloading of the carbon packages, the greatest amount is encountered when the carbon is emptied from the bag into the feeding hopper. This may be minimized by suitable handling procedures, and the scattering of dust may be reduced by installing dust collectors. These usually operate by creating a partial vacuum

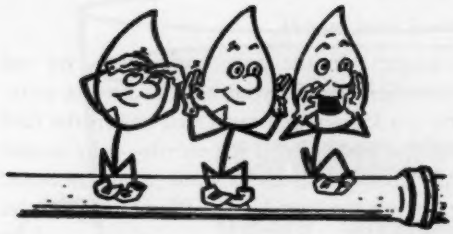
at the hopper door which prevents the escape of carbon particles.

When bag type dust collectors are used, it is essential that the bags be cleaned frequently to maintain maximum efficiency for the dust collecting system. Portable dust collectors equipped with suction hose are now available, and can be used to pick up carbon that has been accidentally spilled or remove carbon dust that has accumulated over a period of time. A barrel or chute to a closed bin should be provided for disposal of the empty carbon bags.

New methods of handling and feeding activated carbon have been investigated and results show that carbon dusting can be practically eliminated by receiving carbon in bulk (closed hopper cars or trailer truck) and using wet storage. Even if it is not feasible to receive bulk shipments of carbon, wet storage has advantages over dry storage, particularly in eliminating dust. When a shipment of carbon is received, the bags may be emptied directly into the wet storage tanks. Wet storage not only eliminates dusting during carbon application, but also eliminates the labor cost of moving carbon both into and out of storage.

The wet storage tank should be equipped with an agitator to maintain a uniform suspension at all times. Proportioning devices such as a Moyno pump, rotometers and weirs may be used for controlling the amount of carbon required for taste and odor conditions.

"Moisturized" carbon may be used where wet storage is not possible. This is carbon of standard quality, differing only in its water content. The amount of water added to minimize dusting is equal in weight to 20 per cent of the carbon.



Percolation and Runoff

New heads and new headquarters came through at the same time last month for A.W.W.A. As of March 1, nominees Berry, Capen and Brush become respectively President-, Vice-President- and Treasurer-Elect and on the same date the Association took over a lease for new headquarters at 521 Fifth Avenue, New York 17, N.Y. Located at 43rd St., the new offices are only a block away from the old corner, but on the 39th floor of a 38-story building they must be at least a block up too. Anyway, if the new heads become big heads after they get crowned in Miami come May 3rd, they'll still find headroom at the new address—to prove to yourself which, *come up and see us sometime!*

Roberts' Rabid Rhabdomanticists, a completely unorganized society for the perpetuation of the persistent popular delusion known as witching, dowsing or divining, is gaining converts faster than any cult we've ever sneered at. What with father diviner Kenneth Roberts' dowsing revelations* high on every best-seller list week after week, we are preparing now for the day when our antagonistic agnosticism in this regard will be dubbed atheism, if not daubed communism. Of course, readers of the miracles of Henry Gross won't necessarily be believers, but we take it as a sad sign that even in the eyes of the New York *Times,* Henry is "nonfiction." And knowing how seriously some of the people who have made the book a best seller take the printed word, we're more than the least bit worried that water works men may have a little trouble getting funds for ground water exploration in the near future. Perish the thought that if the water works men themselves read the book they may not even want the funds.

The gospel of the three R's is, of course, spread in many ways—not to mention our own—but we've yet to find anyone among many newspaper columnists, book reviewers and "scientists," who just out-and-out calls it claptrap. The governor of Massachusetts, among others, has been briefed on the subject by his agricultural experts and has actually had a first-hand

* See March P & R, p. 1.

(*Continued on page 2*)

(*Continued from page 1*)

demonstration of Henry's map magic. In the governor's favor, we can point out that the briefing was unsolicited, unofficial and its results unreported. But the name of Roberts is a known and respected one in the field of letters, and if science isn't based on letters—or even words—why should we, who smoke the cigarette Bing Crosby tells us to smoke, eat the cereal Joe DiMaggio recommends, even drink the liquid Ezio Pinza suggests, let that worry us?

As a matter of fact, it isn't only in the U.S. that a new scourge of sorcery has settled. In Britain, for instance, the disappearance of the famous coronation "Stone of Scone" has brought forth sundry fakirs, fakers and plain fakes not least among whom is a 27-year-old water diviner named Bruce Copen, "who unravels crimes by radioesthesia, a science he invented." Bruce, like Henry, is a mapster, but he dangles a pendulum where Hank twirls a twig—and the vibrations tell him not just about water, but about valuable stones as well. Only difficulty to date has been that the Stone of Scone assays at about two bits. Then from down Argentina way, where we fortunately have our own sources of information, we find other evidence of the worldwideness of witchwanding on a scale that is bound to hamper the work of the conventional water wonder worker. Spieling a witch pitch that is particularly plausible to those who have already swallowed a good deal of mental garbage, Peronia's dowsers are riding so high that even A.W.W.A. has been called into the ring, asked for documentation to quash the quackery.

As one "scientific authority" recently put it: "Since dowsing has been around for thousands of years, there must be something to it." Schmaltz!

National Production Authority regulations, orders, forms, news and related information can be obtained directly from the Dept. of Commerce, Div. of Printing Services, Room 6225, Washington 25, D.C. Those who require this material may ask to be placed on the department's mailing list.

That it's really not the heat but the humidity was conclusively demonstrated just the other day in the basement of Lindy's Restaurant along New York's Broadway. Sleeping down there, Roger Brown failed to wake when a fire broke out in a pile of newspapers and sent flames licking around his legs, but he wasted no time in coming to when the sprinkler system went into action and doused him. Not only that, but water put out the fire which had by then given him third-degree burns of the left leg. Thus did water prevent fire from making fire water fatal.

(*Continued on page 4*)

(*Continued from page 2*)

Jobs are available for qualified persons in water works management, in engineering, in the laboratory, in sales engineering and in similar occupations. Those interested should file a resume of their experience and background with the A.W.W.A. office, which will attempt to channel them to prospective employers.

That lucre really is filthy has now been scientifically established by two medical researchers—B. R. Nisbet and T. Skeoch—whose investigation of the bugs on bucks, i.e., "Bacteria on Bank Notes," was described in a recent issue of the British *Medical Officer*. Water works men hitherto unhappy at their relative unacquaintance with the subject of the experiments, which disclosed the presence of haemolytic streptococci, *Staph. pyogenes* and pneumococci, may thus want to change their minds about the whole thing—at least until the authors' recommendations concerning disinfection procedures are put into practice. On the other hand, if, despite this fair warning, they persist in their desire to get their hands on some moola, they might at least remember that the bigger the bill the less the chance of its contamination.

(*Continued on page 6*)

MIAMI

April 29-May 4—A.W.W.A.'s 71st Annual Conference

(*Continued from page 4*)

Again too much has proved not enough. First at Novato, Calif., oversupply meant insufficiency when heavy winter rains prevented completion of the reservoir that was to have held next summer's supply. Then, last month, too much came too soon again when it was too cold at Columbia, Pa., a frozen flood knocking out the water company's pumping station and putting the community on more than a week of short, but long-distance, rations—a quart per capita per day being trucked in from Lancaster, Pa. Meanwhile, in northern New Jersey reservoirs were brimming and in New York City engineers were totting up even the system overflow to record a bloated 100.8 per cent full—not "not enough" now, but with not enough "frozen assets," perhaps too little, too, later.

And, barring the Southwest, everywhere has seemed all wet. The Pacific Northwest has been running off all over the place, with disastrous results. In Italy, a flooding Tiber has been threatening Rome. And in Britain, the months of January and February hung up a rainfall record of 7.85 in. About all the Southwest has received as yet is ice—unwanted, unexpected, unprepared-for ice—which with its causative cold put water utilities in the area in a real jam, consumption going up precipitously when consumers tried trickling to prevent freeze-ups and up again when the freeze departed and water mains started popping.

Too much, too little, too hot, too cold or even too medium, "everywhere" is where "water, water" must be and must be important.

The proposal under consideration by the House Ways and Means Committee to raise additional federal revenues by taxing local government bonds produced sharp reaction from many quarters. Speaking for a number of municipal organizations, including the United States Conference of Mayors, the American Municipal Assn. and the Municipal Finance Officers Assn., Austin J. Tobin read into the committee's minutes a statement outlining the basic objections to the proposal. In addition to urging the unconstitutionality of the method, his testimony argued that very little additional revenue would be earned by it and, ironically enough, it would prevent many near-marginal but self-supporting projects from being carried through without federal assistance. The result of this would be the illogical gain of a small amount of federal revenue at the expense of either greatly increased appropriations for local government aid or a drastic curtailment in local government services.

Kirk H. Logan, research engineer with the Cast Iron Pipe Research Assn., has been awarded the 1951 Frank Newman Speller Award for corrosion engineering by the National Assn. of Corrosion Engineers. At present experimenting with corrosion prevention, he had long been active in the National Bureau of Standards investigating underground corrosion.

(*Continued on page 8*)

(*Continued from page 6*)

The sanitary status of drinking water supplies used by railroads, buses, ships and airlines has been listed by the U.S. Public Health Service. Previously U.S.P.H.S. had simply checked lists of watering points submitted by public carriers for conformance with its Drinking Water Standards; the issuance of a regular list has now been started to guide public carriers in their choice of supply points. Listed are 1,652 vessel, 1,423 railroad, 179 airline and 2 bus watering points. Additional lists cover milk and frozen dessert sources. The listings were made by U.S.P.H.S. on the basis of state health department reports and will be revised three times a year, appearing the first day of January, May and September. Copies may be obtained from the Federal Security Agency at any of its regional offices.

Stifel W. Jens has opened a consulting office in St. Louis at 101 S. Meramec Ave., where he will practice in hydraulic, hydrologic and sanitary engineering. He had been associated with Horner & Shifrin for the past 18 years, the last 12 as a partner in the firm. He has long been active in the field of hydrology, having taken part in a number of investigations and studies made by national committees and organizations.

(*Continued on page 10*)

(*Continued from page 8*)

Painting oneself into a corner is kid stuff compared with the accomplishments of Messrs. Joseph Vowels and Joseph Vittini of Santa Barbara, Calif. Scientific snowmakers, they, the two Joes went up into the Figueroa Mountains to increase the snow crop for spring harvesting. Only trouble was that each time they started seeding the clouds with silver iodide, the snow would storm down immediately. Next thing they knew, they had snowed themselves not in, but up—on a 3,600-ft. mountain. What's more it took a rescue party several days to fight its way through four-foot drifts to bring them back.

Could this be wisely and still too well?

Havens and Emerson, consulting firm of Cleveland, Ohio, and New York, N.Y., have announced a number of personnel changes. Admitted to the firm as partners are Walter L. Leach, principal engineer, of the New York office, and Harry H. Moseley, civil engineer, and Jasper W. Avery, mechanical engineer, both of the Cleveland office. Frank S. Palocsay and Edward S. Ordway have been appointed principal engineers.

A movie film attack on stream pollution has been opened by the Sanitary Water Board of the Pennsylvania Dept. of Health. Two film versions of the story of the clean streams campaign are being distributed, both in full color and sound. "Dangerous Waters," a 35-mm. 10-minute one-reeler, is intended for theatrical showing; and "Waters of the Commonwealth," a more complete and detailed 25-minute 16-mm. short, is planned for showings at schools, clubs and organizational meetings. Both films were produced by the Jim Handy Organization as part of the drive to enlist continuing popular support behind the state's campaign.

John R. Hartley, manager of project sales for Builders-Providence, Inc., has been elected a vice-president of the company. A veteran of 23 years of service with the organization, Hartley will continue in charge of his department both in the water and sewage field and in the field of industrial water and waste treatment.

Andrew A. Melnychuck has been appointed project engineer of Omega Machine Co., in which capacity he will work on development and research in chemical feeding problems for water supply and other applications.

(*Continued on page 12*)

The water main that never grows old—

"Century"®

ASBESTOS-CEMENT PIPE!

Original installation of "Century" Pipe previous to relaying it at the new lower grade.

Engineers: Tighe and Bond, Holyoke, Mass.
Contractors: Scott Bros., Ludlow, Mass.

Consider the experience of water department officials in South Hadley Falls, Mass.: In 1950, it was decided to add three miles to the existing system of "Century" Pipe. At the same time, it was necessary to relocate several hundred feet of the original pipe to make it conform to the grading plans for a new development area. But, because "Century" Pipe never grows "old", there were no difficulties involved: A trench was dug to the new grade paralleling the original pipe run, and the same "Century" Pipe, with *the same Simplex Couplings was relaid and reused at the new level!*

The high re-use value is just one example of the continuing economies of "Century" Asbestos-Cement Pipe—economies that start with the low cost of the pipe. "Century" Pipe, though exceptionally strong, is light in weight—is economical to ship and store; can be handled easily and laid quickly. It can be cut and tapped in the field. And, because "Century" Pipe never tuberculates and will not rust or corrode, its original carrying capacity never decreases; it does not increase pumping costs; the pipe is always efficient, always "new"!

Before you buy or specify any pipe for water mains, get the complete story on K&M "Century" Asbestos-Cement Pipe. We'll gladly send details upon request.

Nature made Asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos®

KEASBEY & MATTISON
COMPANY · AMBLER · PENNSYLVANIA

K&M Asbestos Rope for yarning bell and spigot joints reduces the hazard of high bacterial content following the laying of water mains. Write for details.

See us at Booths 35 and 36, American Water Works Association Convention, Miami, Florida, April 29 - May 4, 1951

(*Continued from page 10*)

LeRoy H. Scott, sales engineer for Infilco, Inc., in Florida, died on February 28. For many years filtration engineer of the Oklahoma City, Okla., Water Dept., he received the Southwest Section's Fuller Award in 1940 for developing submerged combustion recarbonation equipment and for his part in the Scott-Darcy method of ferric chloride production. He also patented a device for obtaining temperature control of lime slakers, and recently developed a use for lime softening sludge in chemical precipitation for primary treatment of sewage. He joined the Infilco staff after World War II and settled in Orlando, Fla.

H. Seaver Jones has retired as president and director of Centriline Corp. and has been succeeded by James P. Cummins, formerly East Coast general superintendent of the Raymond Concrete Pile Co. Mr. Jones, who will retain his affiliation with the company as a consultant, was associated with the cement lining process almost since its invention by A. G. Perkins twenty years ago. The process was originally developed by the T. A. Gillespie Co., and the Centriline organization was formed in 1939 to promote its use for lining pipe 4 to 144 in. in diameter.

(*Continued on page 14*)

(*Continued from page 12*)

"What Price Water?" seems almost beside the point now that we've received our monthly gasoline bill from Esso Standard Oil Co. What Price Distilling? that's what we want to know, for in a little booklet enclosed with the bill, we learned that "after all, one pound of gasoline costs about four cents, or less than you [us, that is] would pay for the same amount of bread, milk, lumber or distilled water!" What with undistilled water at a nickel a ton and gasoline at $80 a ton, it's no wonder that we pay the price we do for the stuff we like to drink.

Information on government controls is being provided by the New York *Journal of Commerce,* 63 Park Row, New York 15, N.Y., on a subscription basis. Indexes and digests of the controls are kept current by weekly bulletins.

L. A. Dixon, vice president of the meter and valve division of Rockwell Mfg. Co., has been elected a member of the Board of Directors.

Dowell, Inc., has moved its New York office to 45 Rockefeller Plaza, Room 1965, New York 20, N.Y.

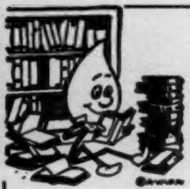
(*Continued on page 16*)

(*Continued from page 14*)

Wolman on Water on WAAM, which is to say that water supply has made its first splash on a new medium—being the subject of television treatment on the March 20 Johns Hopkins Science Review program, conducted by our own Abel Wolman and broadcast by Station WAAM, Baltimore. What with pictures and even micropictures of the subject transmitted over whatever video is transmitted over as part of what has been characterized as "the best program telecast," one of these days one of these televiewers is going to start drinking the stuff.

Red water problems are apparently no one's business but the Reds'. At any rate, when France, the Philippines, Britain and the U.S. jointly introduced a resolution calling upon the Economic Committee of the United Nations Economic and Social Council to sponsor a study of water supplies and development for use in arid regions of the world, the Soviet Union representative objected that the U.S. was advocating interference in the economic affairs of other countries. Something ought to be said about their just deserts.

(*Continued on page 80*)



The Reading Meter

The Practice of Sanitation. *Edward S. Hopkins and Francis B. Elder. Williams & Wilkins Co., Baltimore, Md. (1951) $7.50*

Intended as a textbook and guide in environmental sanitation, the volume presents a summary of modern practice in food handling, insect control, sanitary administration and other fields. Chapters on sewage disposal, stream pollution control and swimming pools are included, and the section on water supplies is a generous 65 pages long, offering a not-too-brief synopsis of the procedures used to make waters safe. The book is not intended to provide new information for water works personnel, but it may incidentally find use as an orientation manual.

Active Carbon. *John W. Hassler. Chemical Publishing Co., Brooklyn, N.Y. (1951) $7.00*

The first complete survey of active carbon to be published in English, according to the publishers, this volume discusses theoretical principles and fundamental concepts of the adsorption process, industrial and water treatment applications, and experimental methods and principles. Background information on the manufacturer and preparation of active carbon (or *activated* carbon, as it is fairly generally and commercially known) is included. The author has long been director of research for the Industrial Chemical Sales Div. of West Virginia Pulp & Paper Co.

The Water and the Power: Development of the five great rivers of the West. *Albert N. Williams. Duell, Sloan & Pearce, New York (1951) $4.50*

This story of the colorful past, desperate present and forbidding future of the Colorado, Sacramento-San Joaquin, Rio Grande, Missouri and Columbia Rivers makes absorbing reading. The author, a professional yarn-spinner, recounts his narrative in chatty and popular form. Perhaps a little too popular, for in his search for human interest and dramatic conflict he has been led to portray some un-

(*Continued on page 20*)

The Reading Meter

(Continued from page 18)

realistically deep-dyed villains—such as, for example, the much-abused people of Los Angeles. Some of the concrete details with which he clothes the bare historical facts may not be as authentic as they are intended to appear, but they make for entertaining reading, and probably no great damage is done by attracting the attention of as many readers as possible to a regional problem of national significance.

Report Preparation. *Frank Kerekes and Robert Winfrey. Iowa State College Press, Ames, Iowa (2nd ed., 1951) $6.90*

Correspondence and technical writing have been included in the scope of the survey of report preparation attempted by this book. Expense has obviously not been spared in the production of the volume, which includes illustrations and samples of actual forms, charts and tables. Even letterheads in their original color have been reproduced to lend a tone of authenticity to the forms which appear on business stationery. The mechanics of illustrating, of verbal expression, of style and format—all are discussed and carefully explained. In addition, the general planning and collection of information required for the reports, as well as their formal preparation, all receive due attention. In general, the store of useful information is exhaustive, and the average report writer may complain—if at all—of too much rather than too little coverage.

Public Health Laws of the City of Pittsburgh. *School of Law, Univ. of Pittsburgh, Pittsburgh, Pa. (1950) $5*

This novel compilation of the laws of a single city is the product of extensive research and, with the notes, fills 1,038 pages.

Correspondence

Nice Mice Vice

To the Editor:

The other day at Norfolk, Va., I was talking with Mr. Wilson Davis who is the man in charge of the distribution system for the city of Norfolk. He tells me that the mice like to eat the A.W.W.A. Journal back sections—where they are pasted together.

For some reason the mice at the Norfolk water works office out at the plant PREFER THE JOURNAL A.W.W.A. TO ALL OTHER JOURNALS.

Mr. Wilson Davis decided that he would catch this mouse and brought a small mouse trap from home. He purchased some ordinary cheese and decided that he would set the trap later in the afternoon just before going home.

The interesting part of this story is that the mouse came out sometime during the middle of the day when all of the men were away, ate the cheese and pushed the wrapping paper into the waste basket.

This is a true story and quite hard to believe, but anyway the mice at Norfolk water works which prefer the Journal A.W.W.A. are pretty smart.

Fred E. Stuart

Pres., Stuart Corp.
516 N. Charles St.
Baltimore 1, Md.; Mar. 19, 1951

Man or mouse, as long as they start with the "back section," we of P&R are happy.—Ed.

Membership Changes

NEW MEMBERS

Applications received February 1 to 28, 1951

Albion City Water Dept., Ralph H. Roberts, Water Comr., 420 W. Market, Albion, Neb. (Corp. M. Jan. '51) *MP*

Allert, Ralph R., City Water Supt., Box 994, Ritzville, Wash. (Jan. '51)

Archbold Board of Public Affairs, George D. Mignin, Pres., 410 Vine St., Archbold, Ohio (Corp. M. Jan. '51)

Ayalon, Naftali, Mgr. & Tech. Director, Ayalon & Etzioni Ltd., Box 586, Haifa, Israel (Jan. '51)

Ballard, Calvin F., City Engr., Grand Prairie, Tex. (Jan. '51)

Belle Alkali Co., Mrs. Ruth B. McBrayer, Sales Mgr., Belle, W. Va. (Assoc. M. Jan. '51)

Benjamin, William, Asst. Operator, Water Purif. Plant, 131 Antoine St., Wyandotte, Mich. (Jan. '51)

Benson, Edward F., Pres., Hemlock Mutual Water Co., 5240 N. Cogswell Rd., El Monte, Calif. (Jan. '51)

Bower, Roy O., Supt., Water Dept., Arcadia, Ind. (Jan. '51) *M*

Bowman, J. M., *see* Studebaker Corp., The

Bowman, W. Robert, Supt., Water & Sewage Treatment, Municipal Bldg., Newark, Ohio (Jan. '51) *MPR*

Bryan, Howard R., Sales Repr., James B. Clow & Sons, 2009 Coleridge Dr., St. Louis 21, Mo. (Jan. '51)

Burden, Martin L., Engr., Martin L. Burden & Assocs., 103½ N. Harrison St., Alexandria, Ind. (Jan. '51) *P*

Burke, George W., Jr., Asst. San. Engr., Public Health Service, Bureau of San. Eng., State Board of Health, Jacksonville, Fla. (Jan. '51) *R*

Byars, Robert L., Supt. & Mgr., San Luis Obispo County, Water Works Dist. No. 2, Morro Bay, Calif. (Jan. '51)

Cansler, William G., Sales Engr., Dresser Mfg. Co., Ltd., 163 Bellechease St., Montreal, Que. (Jan. '51)

Carloss, Leslie, Jr., *see* Carloss Well Supply Co.

Carloss Well Supply Co., Leslie Carloss, Jr., 111 Concord St., Memphis, Tenn. (Assoc. M. Jan. '51)

Carluccio, Daniel, Jr. Engr., Water Dept., City Hall, East Orange, N.J. (Jan. '51)

Catlett, George F., Engr. & Director, State Stream San. & Conservation Com., Box 2091, Raleigh, N.C. (Jan. '51)

Chandler, R. L., *see* Newton (Kan.)

Charles City Water Works, Arthur E. J. Johnson, City Mgr., Charles City, Iowa (Corp. M. Jan. '51) *M*

Colorado Dept. of Public Health, William N. Gahr, Director, Div. of San., 720 Boston Bldg., Denver, Colo. (Corp. M. Jan. '51)

Covington, Town of, C. L. Overholt, Water Supt., Covington, Va. (Corp. M. Jan. '51)

Conservative Water Co., E. E. Pedder, Pres. & Gen. Mgr., 8627 Fir Ave., Los Angeles 2, Calif. (Corp. M. Jan. '51)

Crabtree, Walter R., Co., L. G. Phillippe, 1503 Barnett Bank Bldg., Jacksonville, Fla. (Corp. M. Jan. '51) *M*

Crumley, Clarence C., Chief of Water Sanitation Section, Div. of San. Eng., State Health Dept., Pierre, S.D. (Jan. '51) *P*

Daniels, Paul G., Mgr., Monongahela City Water Co., 111—3rd St., Monongahela, Pa. (Jan. '51)

Davis, David G., *see* Davis Mfg. Co.

Davis Mfg. Co., David G. Davis, Pres., 9250—3rd St., Beverly Hills, Calif. (Assoc. M. Jan. '51)

Denny, Benjamin C., Exec. Secy., City Waterworks, Box 1423, Trenton, Fla. (Jan. '51) *MPR*

(*Continued on page 32*)

(*Continued from page 30*)

Dismukes, George, City Purchasing Agent, City Hall, Colton, Calif. (Jan. '51) *M*

Dunbar, Marion Frank, Cons. Engr., Universal Eng. Co., Box 74, Morgantown, W. Va. (Jan. '51) *MP*

Dyer, R. W., *see* Petersburg (Ind.) Water Works Dept.

Elliott, Charles B., Supt., Water Dept., Board of Public Works, 811 Bell, Beatrice, Neb. (Jan. '51)

Evans, Frederick M., Graduate Student, San. Eng., Univ. of Iowa, Atalissa, Iowa (Jr. M. Jan. '51)

Finke, Herbert A., Water Dept. Foreman, Munic. Light & Water Plant, Huntingburg, Ind. (Jan. '51) *MPR*

Flanigan, Eleanor A. (Miss), Technician, West Palm Beach Water Co., West Palm Beach, Fla. (Jan. '51)

Florence Water Dept., C. W. Severy, Supt., Box 647, Florence, Ore. (Mun. Sv. Sub. Jan. '51)

Fox, Arthur J., Jr., Asst. Editor, *Engineering News-Record*, 330 W. 42nd St., New York 18, N.Y. (Jan. '51) *MPR*

Franklin, Town of, T. B. Noland, Town Mgr., Franklin, Va. (Corp. M. Jan. '51)

Furman, B. A., Sr. Hydr. Engr., Div. of Water Policy & Supply, 127 Beech St., Arlington, N.J. (Jan. '51)

Gahr, William N., *see* Colorado Dept. of Public Health

Gantt, Joseph I., Salesman, Lynchburg Foundry Co., Peoples National Bank Bldg., Lynchburg, Va. (Jan. '51)

Garrett, Melrose T., Jr., Student, San. Eng., Massachusetts Inst. of Technology, 77 Westgate Ave., Cambridge 39, Mass. (Jr. M. Jan. '51)

Geisler, Lloyd, C., Auditor, Dept. of Water Works, 5941 Calumet Ave., Hammond, Ind. (Jan. '51)

General Electric Co., E. O. Potthoff, Application Engr., Industrial Eng. Div., 1 River Rd., Schenectady, N.Y. (Assoc. M. Jan. '51)

Gordon, Harry, Owner, Hunter Water Works, Greene County, N.Y. (Jan. '51) *MPR*

Granger, Dale W., San. Engr., East Lansing, Mich. (Jan. '51)

Grayson, Arthur, Supt., City Water Works, Clermont, Ind. (Jan. '51) *M*

Grimes, Harper D., Supt., City Water Dept., 129 N. 2nd St., Yakima, Wash. (Jan. '51) *MPR*

Gustavson, Arthur William, Chief Clerk, City Water Dept., 1002 Main St., Jacksonville, Fla. (Jan. '51)

Hamilton, D. H., *see* Jetmore (Kan.)

Henderson, William B., Exec. Vice-Pres., Air Conditioning & Refrigerating Machinery Assn., Inc., 717 Southern Bldg., Washington 5, D.C. (Jan. '51)

Higaki, Harold H., Accountant, Board of Water Supply, Box 3410, Honolulu 1, Hawaii (Jan. '51)

Hoosier Water Co., J. B. Wilson, Pres., K of P Bldg., Indianapolis, Ind. (Corp. M. Jan. '51) *M*

Hooton, Cletus E., Service Engr., Electric Chemical Co., 733 Palermo, Coral Gables, Fla. (Jan. '51)

Howard, Harry M., Sales Engr., Pittsburgh-Des Moines Steel Co., 38 S. Dearborn, Chicago 3, Ill. (Jan. '51)

Hughes, Bernard F., Jr., Sales Engr., American Locomotive Co., Alco Products Div., Dunkirk, N.Y. (Jan. '51)

Ingersoll, Alfred C., Instructor, Civil Eng., California Inst. of Technology, Pasadena 5, Calif. (Jan. '51)

Iwamura, Masami, Assoc. Civ. Engr., Board of Water Supply, Box 3410, Honolulu, Hawaii (Jan. '51)

Jefferies, Mildred B., (Miss), Sr. Bacteriologist, Bureau of Labs., State Board of Health, Jacksonville, Fla. (Jan. '51)

Jetmore, City of, D. H. Hamilton, Supt. of Utilities, Jetmore, Kan. (Corp. M. Jan. '51)

Johnson, Albert Edwin, Dist. Engr., U.S. Geological Survey, Water Resources Div., 207 Creason Bldg., Columbia 1, S.C. (Jan. '51) *R*

Johnson, Arthur E. J., *see* Charles City (Iowa) Water Works

Johnson, Charles Donald, Dist Public Health Engr., Dist. Health Service No. 10, Box 356, Centerville, Iowa (Jan. '51) *MPR*

Kempf, August, Supt., Water Dept., Ho-Ho-Kus, N.J. (Jan. '51)

(*Continued on page 34*)

(*Continued from page 32*)

Kensler, Calvin T., Filtration Plant Operator, Munic. Light & Water, Huntingburg, Ind. (Jan. '51) *P*

Knapp, Lloyd D., City Engr., 408 City Hall, Milwaukee, Wis. (Jan. '51)

Knotts, Thomas, Pres., Yankeetown Utilities, Inc., Yankeetown, Fla. (Jan. '51)

Kramer, Harry P., Chemist, Training Section, U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (Affil. Jan. '51)

Kukurin, Frank & Sons, Inc., George W. Kukurin, Secy., Caldwell & Station Sts., Wilmerding, Pa. (Assoc. M. Jan. '51)

Kukurin, George W., *see* Kukurin, Frank & Sons, Inc.

Lathrop, Wellington C., Sr. Civ. Engr., City Water Dept., 229 City Hall, Minneapolis, Minn. (Jan. '51) *M*

Leisenring, J. L., Sales Engr., Pittsburgh Equitable Meter Div. of Rockwell Mfg. Co., 6128 Burlington, Indianapolis, Ind. (Jan. '51)

Limbaugh, James E., Constr. Supt., C. C. Construction Co., 2001 E. Pontiac St., Fort Wayne, Ind. (Jan. '51)

Lindsey, Ray W., Sales Engr., Builders Iron Foundry, Hotel Lincoln, Indianapolis, Ind. (Jan. '51)

Loft, Edward A., Lab. Technician, Windsor Utilities Filtration Plant, 3665 Wyandotte St., E., Windsor, Ont. (Jan. '51)

Mastrogianakis, Nicholas, Regional San. Engr., State Board of Health, Box 210, Jacksonville, Fla. (Jan. '51) *P*

McBrayer, Ruth B., (Mrs.), *see* Belle Alkali Co.

McKim, Township of, A. C. Northover, Township Engr., Sudbury, Ont. (Corp. M. Jan. '51)

Mignin, George D., *see* Archbold (Ohio) Board of Public Affairs

Miller, Frank, Comr., North Jersey Dist. Water Supply Com., 26 Renner Ave., Newark, N.J. (Jan. '51) *M*

Miller, Lynn M., Hydrogeologist, Geological Survey Div., State Dept. of Conservation, 211 Capital Savings & Loan Bldg., Lansing 68, Mich. (Jan. '51)

Moreau Meyer, Jose H., Apartado No. 8, Caracas, Venezuela (Jan. '51)

Nancrede, Henry T., Manufacturers' Repr., 1037 N. Pennsylvania St., Indianapolis, Ind. (Jan. '51)

Nehin, Frank O'B., Supervising Engr., Div. of Water, Foot of Porter Ave., Buffalo 1, N.Y. (Jan. '51)

Neufeld, James C., City Engr., City Hall, 4th Ave., S., Lethbridge, Alta. (Jan. '51)

Newton, City of, R. L. Chandler, Water Works Supt., Newton, Kan. (Corp. M. Jan. '51)

Nicholson, Clifford T., Gen. Foreman, Reclamation Dept., Standard Oil Co. of Ind., Whiting, Ind. (Jan. '51)

Noland, T. B., *see* Franklin (Va.)

Northover, A. C., *see* McKim, Township of

Nussbaum, Ben, Water Works Supt., Fairbury, Ill. (Jan. '51)

Overholt, C. L., *see* Covington (Va.)

Parker, Richard A., *see* San Clemente (Calif.)

Parkinson, G. W., *see* Prairie Farms Rehabilitation Admin.

Paul, Alfred Leroy, Asst. to Mgr. of Operations & Maint. Div., East Bay Munic. Utility Dist., 2127 Adeline St., Oakland, Calif. (Jan. '51) *M*

Pedder, E. E., *see* Conservative Water Co.

Petersburg Water Works Dept., R. W. Dyer, Supt., Petersburg, Ind. (Corp. M. Jan. '51)

Phillippe, L. G., *see* Crabtree, Walter R., Co.

Pletcher, L. Louis, Salesman, Paul Pumps, Inc., 2718 West Dr., Fort Wayne, Ind. (Jan. '51)

Potthoff, E. O., *see* General Electric Co.

Powers, David B., Supt., Public Utilities, U.S. Navy, Navy 115, Box 58, F.P.O., New York, N.Y. (Jan. '51)

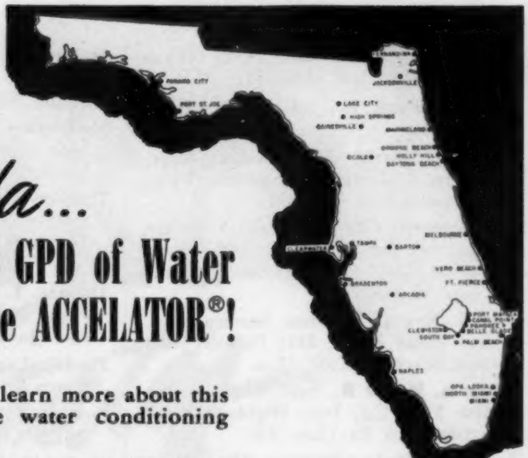
Prairie Farms Rehabilitation Admin., G. W. Parkinson, Design Engr., 910 McCallum-Hill Bldg., Regina, Sask. (Corp. M. Jan. '51)

Probasco, Weller, City Water & Street Supt., City Hall, Newberg, Ore. (Jan. '51) *M*

Proos, John M., Contracting Engr., Layne Northern Co., Inc. 227 W. Edwards Ave., Indianapolis, Ind. (Jan. '51) *R*

Reilly, Robert B., Field Engr., Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J. (Jan. '51)

(*Continued on page 36*)



(*Continued from page 34*)

Richardson, Gene, Supt., City Water Dept., Eaton, Ind. (Jan. '51) *MP*

Roberts, Ralph H., *see* Albion (Neb.) City Water Dept.

Runyan, Marvin W., Design Engr., Stevens & Koon, 1204 Spalding Bldg., Portland 4, Ore. (Jan. '51)

San Clemente, City of, Richard A. Parker, Supt. of Public Works, 408 N. El Camino Real, San Clemente, Calif. (Corp. M. Jan. '51)

Schultz, Rex A., Foreman, Service Dept., City Water Dept., 2911 Fashion Ave., Long Beach 10, Calif. (Jan. '51)

Schumm, Walter B., Sales Repr., Layne-New York Co., Inc., Highland Bldg., Pittsburgh 6, Pa. (Jan. '51)

Severy, C. W., *see* Florence (Ore.) Water Dept.

Shaw, Vance W., Emergency Service Foreman, City Water Dept., 1612 E. Wardlow Rd., Long Beach, Calif. (Jan. '51)

Shipman, James W., Supt., City Water Works, Fulton, Ill. (Jan. '51) *M*

Smith, Charles Leavell, Jr., Supt., Light, Water & Sewerage Dept., Griffin, Ga. (Jan. '51) *M*

Spencer, D. Y., Manufacturers' Repr., Walker Process Equipment, Inc., 1037 N. Pennsylvania St., Indianapolis, Ind. (Jan. '51) *P*

Spratt, Eugene C., San. Engr., Bureau of San. Eng., State Health Dept., Little Rock, Ark. (Jan. '51)

Straub, George H., Asst. Supt., Westchester Joint Waterworks, Box 660, Mamaroneck, N.Y. (Jan. '51)

Stuart Water Co., Fred J. Walton, Supt. of Water System, City Hall, Box 998, Stuart, Fla. (Mun. Sv. Sub. Jan. '51)

Studebaker Corp., The, J. M. Bowman, Supt. of Power Plants, 635 S. Main St., South Bend 27, Ind. (Corp. M. Jan. '51)

Thacker, Earnest L., Field Consultant, League of Virginia Municipalities, 905 Travelers Bldg., Richmond 19, Va. (Jan. '51)

Thomas, T. Bascom, City Water & Light Plant, 29 N. Franklin St., Knightstown, Ind. (Jan. '51) *M*

Tinsley, Logan, Water Works Supt., Van Buren, Ind. (Jan. '51)

Townsend, Fred F., Engr. & Sales Repr., Box 303, Topeka, Kan. (Jan. '51) *P*

Vandivier, Leo, Water Supt., City Heat, Light & Power Co., Bargersville, Ind. (Jan. '51)

Walton, Fred J., *see* Stuart (Fla.) Water Co.

Ward, William David, Asst. Supt., Water Dept., Dade City, Fla. (Jan. '51) *M*

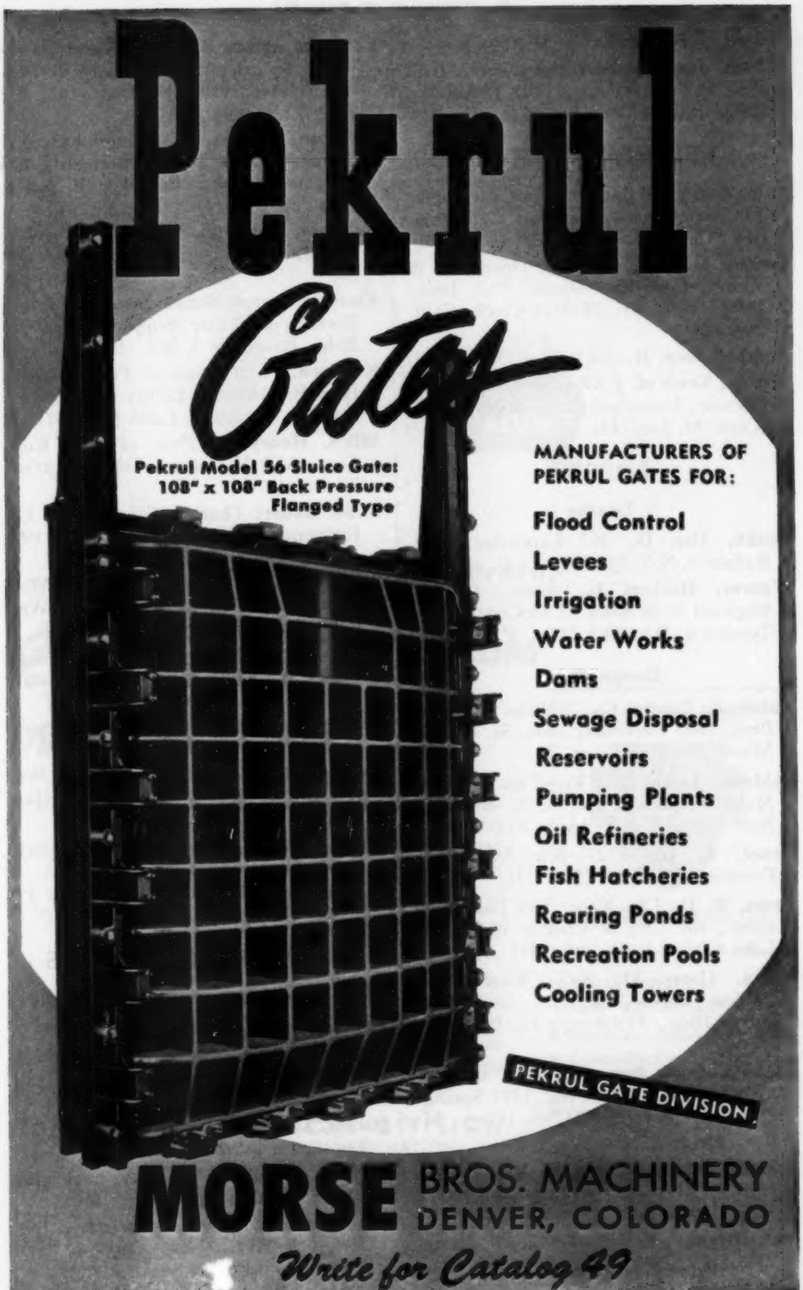
Watson, Donald K., Building Foreman, R. R. Donnelley & Sons Co., Sloan St. Plant, Crawfordsville, Ind. (Jan. '51)

Wehrle, Francis L., Dist. Sales Mgr., Iowa Valve Co., 2127—32nd St., Des Moines 10, Iowa (Jan. '51)

Westgarth, Warren C., Instructor, Civ. Eng., Oregon State College, D-15-Apartment 4, Adair Village, Ore. (Jan. '51)

Whitaker, William T., Supt. Meter Div., Knoxville Utilities Board, Box 1951, Knoxville, Tenn. (Jan. '51)

(*Continued on page 38*)


Pekrul
Gates
Pekrul Model 56 Sluice Gate: 108" x 108" Back Pressure Flanged Type
MANUFACTURERS OF PEKRUL GATES FOR:
Flood Control
Levees
Irrigation
Water Works
Dams
Sewage Disposal
Reservoirs
Pumping Plants
Oil Refineries
Fish Hatcheries
Rearing Ponds
Recreation Pools
Cooling Towers
PEKRUL GATE DIVISION
MORSE BROS. MACHINERY
DENVER, COLORADO
Write for Catalog 49

(*Continued from page 36*)

Wilson, J. B., *see* Hoosier Water Co.

Wilson, James Robert, Sales Repr., U.S. Pipe & Foundry Co., 1204 Praetorian Bldg., Dallas, Tex. (Jan. '51) *R*

REINSTATEMENTS

Cain, Tom J., Maint. Foreman, Metropolitan Water Dist. of Southern California, Box 578, San Jacinto, Calif. (Oct. '43)

Farrell, Louis L., Mgr. of Operation & Maint., East Bay Munic. Util. Dist., 2836 Melillo Dr., Walnut Creek, Calif. (Sep. '22)

Smith J. Guy, Jr., *see* Wilson (N.C.)

Wilson, Town of, J. Guy Smith, Jr., City Chemist, Municipal Bldg., Wilson, N.C. (Corp. M. Jan. '43)

LOSSES

Deaths

Drake, Alan D., 207 Lancaster Ave., Buffalo 9, N.Y. (Jan. '34) *M*

Weaver, Herbert L., Assoc., G. W. Stephens Jr. & Assoc., 5 McCurdy Ave., Towson 4, Md. (Oct. '42) *P*

Resignations

Automatic Control Co., William L. West, Pres., 1005 University Ave., St. Paul 4, Minn. (Assoc. M. Apr. '46)

Baldwin, Leslie A., Vice-Pres., Johns-Manville Sales Corp., 22 E. 40th St., New York 17, N.Y. (Apr. '39) *M*

Bauer, L. G., 1327—8th Ave., San Francisco 22, Calif. (Mar. '31)

Beers, W. D., City Engr., Salt Lake City Corp., 401 City & County Bldg. Salt Lake City 1, Utah (July '44)

Bryan, Harry D., Sales Engr., The Ludlow Valve Mfg. Co., Inc., 1636 Oliver Bldg., Pittsburgh 22, Pa. (July '47)

Commonwealth Eng. Co., The, Malvern J. Hiler, Exec. Vice-Pres., 1771 Springfield St., Dayton 3, Ohio (Corp. M. Apr. '49)

Doland, James J., Prof. of Hydr. Eng., Univ. of Illinois, 317 Civil Engineering Hall, Urbana, Ill. (Nov. '29) *R*

Doll, Byron E., 2305 Snead Drive, Alhambra, Calif. (July '39) *MP*

Edwards, Arthur B., Chief Water Works Operator, Inter-Urban Area of Burlington-Nelson, Burlington, Ont. (Jan. '37) *P*

Foreman, Merle S., Bacteriologist & Chemist, State Board of Health, 825 Cragmont Ave., Berkeley 8, Calif. (Jan. '28) *P*

Kelleher, Joseph T., Supt., Water System, 626 Main St., Martinez, Calif. (Oct. '37) *MP*

Kinnear, Joseph Milton, Sr. Assoc. Engr., Bureau of Water Supply, Municipal Bldg., Baltimore 2, Md. (Jan. '42)

Knudsen, H. A., Special Project Engr., East Bay Munic. Utility Dist., 512—16th St., Oakland 4, Calif. (Oct. '37) *M*

Miles, Henry J., Prof. of Civ. Eng., Texas A & M College, College Station, Tex. (July '41) *PR*

Mills, Robert Charles, Sales Engr., Lee Redman Equipment Co., 610 S. 19th Ave., Phoenix, Ariz. (Oct. '49) *P*

Simmons, John G., Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach, Fla. (Jan. '47) *MPR*

Swab, Richard K., Civ. Engr., Jones, Henry & Schoonmaker, 821 Security Bldg., Toledo 2, Ohio (Jan. '48) *P*

Thomas, Harold E., U.S. Geological Survey, Washington, D. C. (Jan. '49) *R*

Tongate, Ray E., Sales Eng., Thorpe Well Co., Box 1376, Des Moines, Iowa (Jan. '50) *R*

Tripp, Garner C., Jr., Asst. Supt. & Engr., Dept., Glens Falls, N.Y. (Jan. '41) *M*

Ward, Sylvester E., 2238 Greenside Pl., Scotch Plains, N.J. (Jan. '43) *MP*

CHANGES IN ADDRESS

Changes received between February 5 and March 5, 1951

Alton, Lloyd, Asst. Secy. & Treas., Illinois Cities Water Co., Robinson, Ill. (Jan. '48)

Barker, L. V., *see* Merritton Water Works Dept.

Bennett, Boyd A., 767 Bay Esplanade, Clearwater, Fla. (Jan. '37) *MPR*

Boyd, George E., Koppers Co., Inc., 350—5th Ave., New York 1, N.Y. (May '31) *P*

(*Continued on page 40*)

(*Continued from page 38*)

Buhrman, Gilbert W., *see* Monsanto Chemical Co.

Bunker, George C., Cons. Engr., Apdo. 630, Quito, Ecuador (Feb. '11) *Honorary M. '43.*

Byrne, Walter S., Gen. Mgr., Metropolitan Utilities Dist., 18th & Harney Sts., Omaha 2, Neb. (Oct. '39)

Cathodic Rustproofing Co., B. R. Love, Carrizzo Springs, Tex. (Assoc. M. Oct. '44)

Crane, H. E., *see* Koppers Co., Inc.

Detweiler, John C., Mgr., Water Operation Dept., Metropolitan Utilities Dist., 18th & Harney Sts., Omaha 2, Neb. (Mar. '30) *Director '47-'50. Fuller Award* '50. *MP*

Dickson, W. K., 1956 Sterling Rd., Charlotte 7, N.C. (Apr. '38) *P*

Dow, Arthur L., Supt., Board of Public Utilities, Paris, Tenn. (Apr. '49)

Driskell, Thomas E., *see* Morton Salt Co.

Fawls, James F., Engr., Wallace & Tiernan Co., Inc., 162 Colony Rd., Silver Spring, Md. (Apr. '47) *MP*

Fooks, Jack H., U.S. Public Health Service, Room 200, 69 W. Washington St., Chicago 2, Ill. (Jan. '47) *PR*

Francis, J. H., *see* Tavistock (Ont.) Public Utilities Com.

Fredenall, John W., Mgr., F. J. Moran & Son, Pipeline Div., Route 1, Palmer Canyon, Claremont, Calif. (Apr. '50)

Garman, Glenn, Sales Engr., Biggs Pump & Supply Inc., 52 By Pass, Lafayette, Ind. (Oct. '48)

Garrett, L. L., Supt., Water Dept., Utilities Com., Orlando, Fla. (Jan. '49) *M*

Hamtramck Water Dept., Alexander Smolenski, Supervisor, 3201 Roosevelt St., Hamtramck 12, Mich. (Corp. M. Apr. '44) *M*

Hernandez, Donald J., Preventive Medicine Dept., M.F.S.S., Fort Sam Houston, Tex. (Jan. '48) *P*

Hoge, Charles C., III, c/o Thomas A. Monk, Jr., 30 S. Queen St., York, Pa. (Jan. '50) *PR*

Hoppe, T. C., Black & Veatch, Cons. Engrs., 4706 Broadway, Kansas City 2, Mo. (July '45) *P*

Horn, A. John, Arabian American Oil Co., Box 1431 A, Dhahran, Saudi, Arabia (July '39)

Howard, C. M., Engr., Concrete Products Assn. of Washington, 328—3rd Ave., W., Seattle 99, Wash. (Apr. '43)

Judge, James H., Sales Mgr., Gasoline, Oil & Industrial Meters, Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa. (Apr. '34) *M*

Kallin, Francis J., Supervisor, San. Eng. Section, Plant Eng. Office, Ford Motor Co., Dearborn, Mich. (Jan. '50) *P*

Koppers Co., Inc., H. E. Crane, Product Mgr., Koppers Bldg., Pittsburgh 19, Pa. (Assoc. M. Mar. '25)

Lompoc Light & Water Dept., Emil Scolari, Mgr., 118 N. H St., Lompoc, Calif. (Corp. M. Apr. '30)

Loucks, Donald A., Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '49)

Love, B. R., *see* Cathodic Rustproofing Co.

McCabe, Joseph, Asst. Prof., School of Eng., Manhattan College, New York 71, N.Y. (July '47)

McCord, R. K., *see* Norton (Va.)

McGahan, Claude R., Acting Water Supt., Water Dept., City Bldg., El Dorado, Kan. (July '44)

Mellen, Arthur F., 3104 Dupont Ave., N., Minneapolis, Minn. (Mar. '15) *Fuller Award '43. MP*

Merritton Water Works Dept., L. V. Barker, Supt., Town Hall, Merritton, Ont. (Corp. M. June '26) *M*

Monroe, Owen, Vice-Pres. & Treas., Heldt-Monroe Co., 217 S. Bedford Ave., Evansville 9, Ind. (Oct. '42) *PR*

Monsanto Chemical Co., Gilbert W. Buhrman, Mgr., Heavy Chem. Sales Dept., 1700 S. 2nd St., St. Louis 4, Mo. (Assoc. M. Apr. '37)

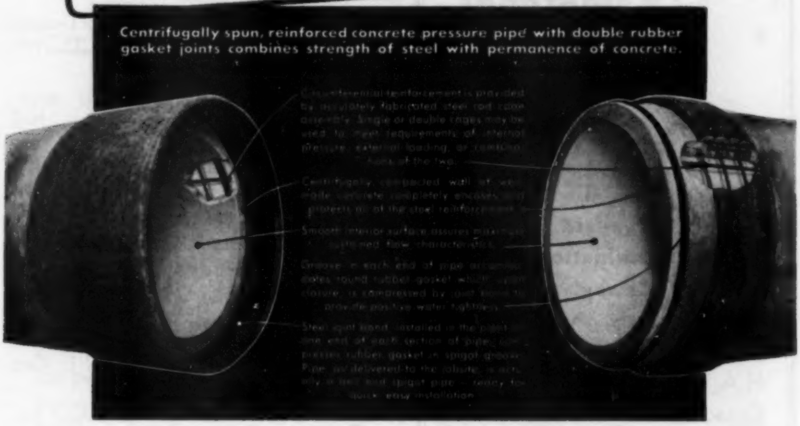
Moore, Carl C., Dist. Mgr., Pittsburgh Equitable Meter Co., 8 E. Long St., Columbus, Ohio (Apr. '39)

Morton Salt Co., Thomas E. Driskell, Mgr., Water Softening Div., 580 E. Town St., Columbus 15, Ohio (Assoc. M. Oct. '37)

Norton, Town of, R. K. McCord, Norton, Va. (Corp. M. Jan. '25)

(*Continued on page 42*)

Could the dependable qualities of this pipe help you reduce the cost of delivered water?



In recent years, development by this company of the Double Rubber Gasket Joint for centrifugally spun pipe has greatly increased its versatility and adaptability. It is proving outstandingly successful in a wide variety of installations throughout the West. Here are typical examples:

Coachella Valley County Water District, Coachella, Calif. (U.S. Bur. of Reclamation Project), Units 5, 6 and 7—270,000′, 12″ thru 72″; operating heads up to 75′.

Olympia, Wash. (McAllister Springs Water Supply Line) 35,000′, 36″; operating head, 150′ max.

San Diego County Water Authority (San Diego Aqueduct–Sweetwater Extension) 23,500′, 18″–24″; operating heads up to 130′.

Available in diameters from 12″ through 84″, and for moderate operating heads (generally up to 125′), this pipe is another example of American's ingenuity and skill in the development of better products for water supply lines. Further information is available upon request.

American PIPE AND CONSTRUCTION CO.

Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

P. O. Box 3428, Terminal Annex, Los Angeles 54, California

Main Offices and Plant—4635 Firestone Blvd., South Gate, Calif.

District Sales Offices and Plants — Oakland • San Diego • Portland, Ore.

(Continued from page 40)

Omaha Metropolitan Utilities Dist., Walter S. Byrne, Gen. Mgr., 18th & Harney Sts., Omaha 2, Neb. (Corp. M. Apr. 12)

Pavanello, R. P., World Health Organization, 42, Via Valadier, Rome, Italy (Oct. '49)

Perkins, Frank P., Dist Mgr., The Deming Co., 2411 Saratoga St., Omaha 11, Neb. (Jan. '49)

Plunkett, Joseph A., Reservoir Supt., 612 Ridge Rd., Cedar Grove, N.J. (Jan. '43)

Poulsen, Russell E., Chemist, Filtration Plant, 555 Lincoln St., Evanston, Ill. (Jan. '47)

Radcliffe, Dewey M., Headquarters, Japan Logistical Command, Eng. Section 13, APO 343, c/o Postmaster, San Francisco, Calif. (Jan. '41) *PR*

Reid, Joseph Y. L., Chief Chemist, Filtration Plant, Trenton 8, N.J. (Oct. '38)

Robinson, Joe Leslie, 3806 Sherwood Dr., Fort Worth 7, Tex. (Jul. '47) *MPR*

Rutherford, Kyle W., 7 Arcadia St., Cambridge 40, Mass. (Oct. '49)

Scolari, Emil, *see* Lompoc Light & Water Dept.

Shanaman, R. H., *see* Welsbach Corp.

Sieveka, Ernest H., Water Resources Div., U.S. Geological Survey, Washington 25, D.C. (Apr. '42)

Travistock Public Utilities Com., J. H. Francis, Chairman, Tavistock, Ont. (Corp. M. July '41)

Tupper Lake Munic. Water System, G. Ward Yoemans, Mgr., 93 Park St., Tupper Lake, N.Y. (Mun. Sv. Sub. Oct. '42)

Wagner, Harold, Supt., Munic. Light & Water Dept., 110 W. Main, Sebewaing, Mich. (July '49)

Welsbach Corp., The, Ozone Processes Div., R. H. Shanaman, Tech. Asst. to Pres., 1500 Walnut St., Philadelphia 2, Pa. (Assoc. M. Jan. '40)

Wright, John D., Box 243, Allentown, Pa. (Jan. '49)

Yoemans, G. Ward, *see* Tupper Lake Munic. Water System

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.R.—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

Pectin-Fermenting Coliform Bacteria. I. Incidence in Water. S. A. Marroquín & B. Farrera. Rev. Soc. Mex. Hist., **8**:47 ('47). A study has been made to det. the incidence in water of pectin-fermenting coliform organisms. Of 51 strains of coliform organisms isolated from water only 2 fermented pectin; one of these strains was an *Aerobacter* intermediate and the other an *Esch. coli* intermediate. Both produced acid and gas. It was concluded that the incidence of pectin-fermenting bacteria in water was negligible and that it was not possible to establish their sanitary significance.—*W.P.A.*

The Membrane Filter in Water Bacteriology. H. Kruse. Gesundh. Ing., **70**:154 ('49). The development of the use of membrane filters in the bact. examn. of water is reviewed in a brief summary of literature on methods of isolating various bact., of measuring the pore size of the filters, and of transferring the filter itself to nutrient medium instead of washing the residue off the filter and transferring it to nutrient medium. The author then describes apparatus used for the detn. of the content of *Esch. coli* in water. Measured vols. of water are filtered through membrane filters with an effective diam. of 3.2 cm., 0.1 mm. thick, and with pore size varying from 0.7 to 2μ; the filter is fixed in the apex of a funnel, and the water is drawn through by a vacuum pump. After all the water has passed through, the filter is dried by continuing pumping for about half a minute and is then transferred to the surface of soft Endo medium, with the collected bact. on the upper surface of the membrane, and incubated at 37°C. The medium diffuses through the membrane and, if *Esch. coli* are present, visible colonies develop on the surface. Under each colony a dark red spot appears in the membrane itself. The colonies can be transferred directly to other nutrient media. To detect the presence of *Esch. coli* of warm-blooded origin, the membrane filter can, after the water has passed through, be cut in half; one half is incubated on Endo medium at 41°C. and the other in tubes of Bulir's neutral red-mannitol soln. (with Durham tubes) at 45°C. The membrane filter method can also be used for detection of *B. typhosum*; using Wilson and Blair's medium, a few typhoid bacteria can be detected in the presence of large numbers of *Esch. coli.* Expts. on the use of the method for estn. of total bact. count have not been completely successful. If membrane filter with bact. is laid on filter paper soaked in dye the color diffuses through; if the membrane is then dried and placed in cedar wood oil it becomes transparent and can be examd. microscopically, but when the count is small the colonies are too scattered to count with accuracy; if larger amts. of water are used, trapped dirt interferes and dead bact. cannot be distinguished from living.—*W.P.A.*

(Continued on page 46)

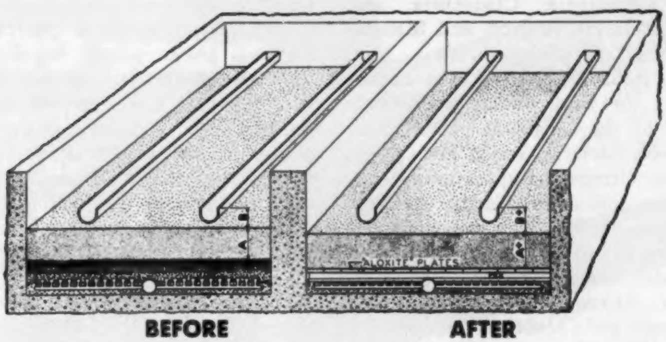
(*Continued from page 44*)

The Influence of the Composition of the Medium on the Growth of Bacteria From Water. C. H. Foot & C. B. Taylor. Proc. Soc. App. Bact. 1:11 ('49). Comparative plate counts were made using dild. samples of lake water on "Standard Medium" with the following compn.: peptone 0.5 g., sol. casein 0.5 g., sol. starch 0.5 g., glycerol 1 ml., K_2HPO_4 0.2 g., $MgSO_4 \cdot 7H_2O$ 0.5 g., $FeCl_3$ trace, agar 15 g., and distilled water 1000 ml., and with variations of this agar. The counts were not influenced by the addn. of carbohydrates to the std. agar. Peptone or casein proved necessary as a source of N. Increasing the concn. of peptone had a restrictive action and counts on beef + peptone and beef + peptone + salts; numbers, however, were consistently lower than on std. medium. Starch and glycerol in the std. medium have no beneficial effect and casein was also found to be superfluous. The presence of beef and peptone in the agar increased colony size. A medium composed of 0.05% peptone, 1.5% agar and the salts was found to be as productive in number of colonies produced as the std. medium.—*P.H.E.A.*

A Bacteriological Investigation Concerning a New Filtrating Mass for the Purification of Waters. E. Edlinger. Ann. Hyg. Pub. Ind. Soc., **28**:38 ('50). The properties of the "Photonic" or K. Hofer method for the purification of water are studied. The filtrating mass is composed of Ag activated by radiations of low freq. and pptd. on a limestone (0.5–1 mm. granulations) or asbestos support. The quants. of these masses are calcd. to permit a contact of 1–2 min. with the filtrating water. According to the expts., the "Photonic" method completely purified water infected with *Esch. coli, S. typhi, S. paratyphi* B, *Shigella dysenteriae, Vibrio comma,* and a white staphylococcus at various

(*Continued on page 48*)

Planning to rebuild old shallow filters?



ALOXITE underdrains offer "extra dividend" features.

For operators of shallow filters, ALOXITE porous bottoms give all the basic benefits that follow elimination of graded gravel support. Moreover, they pay "extra dividends" by solving certain problems inherent in operating such units:

- When rebuilding old-style filters (see "Before") to get proper wash rates, these porous plates permit you to lower filter media. Back washing can then be stepped-up to use greater available distance (B+) to wash gutters. And with the "After" design you profit by a simultaneous increase in operating head for filtration. Where necessary, the filter media bed can be deepened (A+) as porous plate construction supplies a lot of added space.
- In designing new filters, topography may be such that available head is very limited and critical. Here the extra head provided by the construction of ALOXITE filter bottoms may solve the problem.

When seeking ways and means of improving your filters, don't overlook ALOXITE aluminum oxide porous plates. For shallow filters — or *any other type of filter* — underdrains of this type have proved to be distinctly superior.

EVIDENCE: There are nearly 300 installations of ALOXITE filter bottoms in operation today — *some of which are in their 15th year of service!*

REASONS: You'll find them in our new 56-page booklet "Porous Media for Filtration and Diffusion." It's a complete reference handbook — contains a wealth of useful charts, graphs, and photos. A copy is yours for the asking.

THE CARBORUNDUM COMPANY

Dept. O-41, Refractories Div. Perth Amboy, New Jersey

"Carborundum" and "Aloxite" are registered trademarks which indicate manufacture by The Carborundum Company.

(*Continued from page 46*)

dilns. After filtration, the water can even be used at a diln. of 1:100 to disinfect untreated water.—*C.A.*

The Filamentous Bacteria Sphaerotilus, Leptothrix, Cladothrix, and Their Relation to Iron and Manganese. E. G. Pringsheim. Phil. Trans. **B233**:453 ('49). The author reviews the work of various investigators on the Chlamydo bacteriaceae, or sheath bacteria, which are subject to many changes of appearance, making them difficult to identify and causing some confusion in nomenclature. From results of exptl. work the author concludes that there are only two genera: *Sphaerotilus,* reproducing by swarmers, and *Crenothrix,* reproducing by conidia. The author exptd. chiefly with *Sphaerotilus natans* and its reversible modifications, *Leptothrix ochracea* and *Cladothrix dichotoma.* Natural growths of *S. natans,* composed chiefly of soft, elongated, parallel threads, develop best in pold. running water, *C. dichotoma* commonly found in water with decaying leaves, unless, like the leaves of *Quercus* and *Populus,* they contain tannin. *L. ochracea* appears to develop mainly when there is a considerable amt. of ferrous salts present; under these conditions the threads of the *Cladothrix* form deposit ferric hydroxide until they assume the *Leptothrix* condition. The thin primary sheath is org., and becomes coated with inorg. deposits of iron compounds. It has not yet been proved that these iron bacteria are capable of an autotrophic existence, although it is probable that they use the energy derived from the oxidation of inorg. substances. Con-

(*Continued on page 50*)

(*Continued from page 48*)

siderable growth can be obtained when only a small quant. of org. matter is present, and the presence of oxidizable manganous and ferrous compounds causes a considerable increase in the amt. of cell material formed. This supports hypothesis that the bacteria use inorg. oxidation energy, and that small amounts of org. substances are required to keep the iron in ferrous condition. These bacteria also capable, under certain conditions, of ordinary heterotrophic existence.—*W.P.A.*

Bismuth Sulphite Agar in the Cultivation of Typhoid and Paratyphoid Bacilli. I. Lovrekovich. Veröff Kgl. Ungar. Staat. Hyg. Inst., No. 11 ('41). Known that considerable skill is required if satisfactory and consistent results to be obtained in tests for enteric pathogenic organisms with Wilson and Blair's medium. Many different modifications of Wilson and Blair's medium tested by author to increase selectivity and improve the colonial differentiation between pathogenic and nonpathogenic organisms, and to devise a method of prepn. which would insure reproducible results. In the method chosen a mixt. is prepd. contg. glucose, dibasic sodium phosphate, bismuth ammonium citrate, anhydrous sodium sulfite, ferrous ammonium sulfate and brilliant green. One part of this mixt. is added to 5 parts of nutrient agar containing peptone, sodium chloride and dibasic sodium phosphate, with a final pH of 7.2. Detailed instructions are given for the prepn. of the medium. The completed medium is a very complex oxidation-reduction system.—*W.P.A.*

Antiseptic Sea Water. Am. J. Pub. Health, **39**:1349 ('49). In discussion of work by Ketchum, Carey and Briggs, suggested that the mortality of coliform bacteria in ordinary sea water may be due to lack of necessary foodstuffs rather than to the presence of antibiotic or other antibacterial substances. Lower death rate in sea water sterilized by autoclaving than in boiled sea water may indicate that the process of autoclaving produces split products which enable the coliform bacteria to maint. themselves more efficiently.—*W.P.A.*

CHEMICAL ANALYSIS

Polish Water Hardness Degree. Henryk Przylecki. Gaz, Woda i Tech. Sanit. (Poland), **24**:261 (July–Aug. '50). Author first defines other hardness degs. as follows: 1 German deg. of hardness equiv. to 10 ppm. CaO, 1 French deg. equiv. to 10 ppm. $CaCO_3$ and 1 Eng. deg. equiv. to 1 gpg. $CaCO_3$. Much conflict can occur since chem. forms of hardness expressed in terms of CaO or $CaCO_3$ and

(*Continued on page 52*)

(*Continued from page 50*)

it is difficult to compare individual results. Paper discusses proposal of Prof. Kirkor to define Polish deg. as being equiv. to 10 ppm. Ca of water, which incidentally was suggested by present author some years ago. Author strongly feels that hardness should be expressed similarly to all other constituents found in water, namely, in terms of ions themselves, as for example, Ca and Mg, and not in terms of $CaCO_3$ as in America.—*Conrad P. Straub.*

Calculation of the 48-Hour Oxygen Demand. H. J. MEYER. Vom Wasser, **16**:66 ('43–'44). The Flusswasser-Untersuchungsamt of Breslau makes regular anals. of samples of water from Oder R., and the 48-hr. biochem. oxygen demand is included in these anals. During the war, however, there were frequently delays in receipt of samples at the laboratory, and it was therefore necessary to calc. the 48-hr. demand from detns. made after longer period. Expts. showed that calcs. made according to the formulae of Pleissner or of Fair gave inaccurate results, and it was concluded that this was because the river water contd. some decomposing nitrogenous compds. which caused nitrification to occur in the early stages of incubation, and because of the presence of org. compds. possibly derived from sulfite pulp mills, which are decomposed only slowly. A graph has been constructed from which the 48-hr. demand can be read if the demand after 3–10 days is known; it is emphasized that this graph applies only to water from the Oder R.—*W.P.A.*

Effect of Temperature on pH of Alkaline Waters. J. GREEN. Ind. Eng. Chem., **41**:1795 ('49). A study has been made of the change of pH value with temp. in waters of different total alky. and results obtained experimentally compared with those obtained by theoretical calcns. Measurements were made at temps. of 25°, 60° and 90°C. of the pH value of samples of water contg. increasing amts. of alky. From the results graphs have been drawn showing changes in pH value with temp. at constant alky. In general the effect of temp. on pH value was less experimentally than theoretically. Exptl. data substantiate the validity of the calcd. values obtained by Langelier. Factors affecting practical application of the data are discussed.—*W.P.A.*

Standard Methods of Water Analysis and Interpretation of Results. G. E. MARTIN ET AL. Am. Ry. Eng. Assoc. Bul., **490**:222 (Nov. '50). The Railroad Water Service Com. is recommending inclusion, in the A.R.E.A. Manual of Recommended Practice, of the Schwarzenbach method for determining Ca and Mg hardness in water, using disodium ethelenediaminetetraacetate solution; one ml. equals one mg. as $CaCO_3$ with Eriochrome black T for total hardness indicator and ammonium purpurate for Ca.—*R. C. Bardwell.*

Rapid Methods of Determining Sodium and Potassium. H. MESTAYER. L'Eau (Fr.), **36**:174 (Nov. '49). In usual methods of anal., K and Na together expressed as Na. New methods: Ppt. Na^+ as "Streng" salt: $(CH_3CO_2)_2$ Na + $(CH_3CO_2)_2$ Mg + $3(CH_3CO_2)_2$ UO_2 + $8H_2O$. Det. uranium colorimetrically with 1% soln. of ferrocyanure. "Kahane reagent": uranyl acetate 32 g., Mg. acetate 100 g., cryst. acetic acid 20 ml., alc. (95%) 500 ml., distd. H_2O 1000 ml. Evaporate 20 ml. H_2O, redissolve with 1 ml. distd. H_2O, decant by centrifuging; repeat operation. If concn. of Na less than 3 ppm. more than 20 ml. H_2O must be evapd. Ppt. with 8 ml. Ka-

(*Continued on page 54*)

(*Continued from page 52*)

hane reagent, let stand 30–45 min., centrifuge 10 min., decant, wash with 1.5–2 ml. alc. satd. with Streng salts, centrifuge, decant twice. Redissolve ppt. in certain quant., dist. H_2O contg. 2% acetic acid (quant. varies with Na content; 3–15 ppm. Na 50 ml., 15–30 ppm. Na 100 ml.). Place 10 ml. Streng soln. in colorimetric tube and add 10 ml. of 1% K ferrocyanide; brown color develops proportionally to uranium and consequently to Na present. Wait 3 min. before color comparisons made. Interferences: K with concn. of more than 4 g./l.; lithium, strontium, Na, and PO_4: 0.5 ppm. K^+ ppt. as K and Na cobalt nitrate ($(CO(NO_2)_6)$ NaK_2: Titrate with permanganate. Reagents (Billeman), Soln. A: Cobalt nitrate 50 g., acetic acid 25 ml., dist. H_2O 100 ml. Soln. B: $NaNO_2$ 120 ml., dist. H_2O 180 ml.; wash soln. with acetic acid 120 ml., Na acetate 120 g., dist. H_2O 1,000 ml.; Titer: permanganate N/300 or N/80. Procedure: evap. 20 ml. H_2O, redissolve in 1 ml. dist. H_2O, decant twice; ppt. 3 ml. with 1 ml. soln. A and 5 ml. soln. B, stir 1 min., let stand 45–60 min. at 20–25°C., centrifuge 6 min., decant, wash with 1.5 ml. washing soln., dissolve ppt. in 0.5 ml. concn. H_2SO_4 and add rapidly 5 ml. dist. H_2O, titrate with permanganate, heat to 40°C., det. color after 5 min. Interferences: NH_3 must be removed previously with 10 N/NaOH.—*W. Rudolfs.*

Determination of Total Hardness by Gad and Manthey and a New and Quick Method for the Determination of the Sulfate Content. H. J. Meyer. Gesundh. Ing. 71:186 ('50). A modified method of Gad and Manthey for the detn. of the total hardness in river water was described. The $Na_4P_2O_7$ soln. was standardized against a $MgCl_2/CaCl_2$ soln. of 56° *d* whereby 50 ml. corresponded to 10 ml.

(*Continued on page 56*)

(*Continued from page 54*)

of 0.1*N* $Na_4P_2O_7$. After detg. the CO_3 hardness with HCl and methyl orange, the soln. was discolored by boiling 5 min. with NaClO, titrated with KOH to a blue color, using a mixed indicator consisting of bromothymol blue and phenolphthalein, and then treated in the usual manner with $Na_4P_2O_7$. In order to det. the sulfate content in the same soln., a certain quantity of 0.1*N* $Ba(NO_3)_2$ (for details see table in original) was added and, after 5-min. boiling, the soln. was titrated again with $Na_4P_2O_7$.—*C.A.*

CORROSION

Intercrystalline and Other Types of Corrosion of Steam Boilers. R. E. Coughlan et al. Am. Ry. Eng. Assoc. Bul., **490**:223 (Nov. '50). Recommendation was made that in conditioning water for steam boilers on railroads, the sulfate–alky. ratio outlined in the A.S.M.E. Boiler Code which has been found of questionable value and increases operating difficulties, be disregarded and that lignin or nitrate treatment be used where embrittlement detector specimens indicate water of questionable character.—*R. C. Bardwell.*

Methods and Materials for Protection of Underground Pipe Lines. H. E. Graham et al. Am. Ry. Eng. Assoc. Bul., **490**:225 (Nov. '50). No type of protection suitable for all conditions and method selected depends on economics involved. Bituminous and petroleum-base coatings with chromate rust inhibitor have proven satisfactory under some conditions, as well

(*Continued on page 58*)

(*Continued from page 56*)

as Portland cement mortar.—*R. C. Bardwell.*

Electrochemical Studies of Protective Coatings on Metals. F. WORMWELL & D. M. BRASHER. J. Iron Steel Inst., **162**:129 ('49); **164**:141 ('50). I. Electrode Potential Measurements on Painted Steel. In previous expts. on the use of measurements of elec. potential to det. the protection from corrosion afforded by coatings of paint, observations were not made over a sufficient period. The authors describe a technique whereby the changes with time of the electrode potential of painted steel immersed in artificial sea water could be measured over long periods. Found that when the measurements were continued for several weeks, the potential at first fell and then increased to a max. before it gradually fell to more negative values. The period required to pass the max. is an indication of the useful life of the paint under the conditions studied. The authors describe the use of the technique to investigate the effect on corrosion of the thickness of paint, the type of surface finish on the steel, the method of treatment of the metal before painting, and the type of paint. II. Resistance and Capacitance Measurements on Painted Steel Immersed in Sea Water. As the interpretation of electrode potentials is complex the authors have extended the technique described in Part I to include measurements of electrical resistance and capacitance. The apparatus used is described. It was found that curves in which changes in capacitance, log resistance, and conductance were plotted against time could be closely correlated with curves showing the area rusted. A sudden increase in capacitance and conductance gave a good indication of the onset of rusting. Measurements of capacitance could also be used to obtain information about the properties of the film of paint, such as thickness and amount of water absorbed, during the early stages of immersion.—*W.P.A.*

Protection Methods for Cast Iron and Steel Pipes. J. E. CARRIERE. Gas J., **259**:96 ('49). Practical experiences in the corrosion of cast iron and steel pipe lines in water supply systems and gas undertakings in the Netherlands are discussed in relation to the regulations of the Central Corrosion Com. for the external protection of pipes. Examn. of corroded pipes has shown that, where damage has occurred, pipes have been inadequately protected or the protective coatings have been damaged during laying. A committee set up to investigate the behavior of various protective coatings under practical conditions. In discussion, experiences in Great Britain compared with those in Netherlands. Length of service of pipes and types of protective coatings used are compared and the use of internal protective coatings and the disadvantages of hessian and other organic wrappings used for improving the mechanical strength of bitumen coating are discussed.—*W.P.A.*

SURFACE SUPPLIES

Surface Water Supply of the United States 1947. Part 1. North Atlantic Slope Basins. C. G. PAULSEN. U.S.G.S. ('50). This report was prepared by the U.S. Geological Survey in cooperation with Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia, and other agencies. Volume is one of a series of 14 reports presenting results of measurements of stage and flow made on streams, lakes and reservoirs in the U.S. during the water year ending Sept. 30, '47. The

(*Continued on page 60*)

(*Continued from page 58*)

base data collected at gaging stations in the North Atlantic Slope Basins consisted of records of stage, measurements of dischg., and general information used to supplement the records of stage and dischg. measurements in detg. the daily flow. At most gaging stations in the northern U.S. and at some in the mountainous regions of other parts the stage-dischg. relation is affected by ice during the winter, which makes it impossible to compute dischg. in usual manner. Dischg. for periods of ice effect is computed on basis of the gage-height record and occasional winter dischg. measurements, consideration being given to the available information on temp. and pptn., notes by gage observers and engrs., and comparable records of dischg. for stations in the same or nearby basins.—*P.H.E.A.*

Surface Water Supply of the U.S. 1948. Part 4. St. Lawrence River Basin. Geological Survey Water-Supply Paper 1114 ('50). This volume was prepared in cooperation with Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Vermont and Wisconsin and other agencies, and explains the surface water supply of the St. Lawrence R. Basin. The location, drainage area, average and max. dischg. of streams and lakes in this basin are given and rating tables show the findings by day, month, and year.—*P.H.E.A.*

Surface Water Supply of the United States 1948. Part 9. Colorado River Basin. Geological Survey Water-Supply Paper 1119 ('50). This volume, devoted to the Colorado R. Basin, is the ninth in a series of 14 reports showing the results of measurements of stage and flow made on streams, lakes, and reservoirs in the U.S. during the water year ending Sept. 30, '48. Detailed information includes location, drainage area, available records, avg. max. and min. dischg. of water in this area. A list of locations is given where copies of water-supply papers and other publications of the Geological Survey containing data on the water resources of the U.S. may be obtained or consulted.—*P.H.E.A.*

Surface Water Supply of the United States 1948. Part 10. The Great Basin. Geological Survey Water-Supply Paper 1120 ('50). The Great Salt Lake Basin is discussed in this volume which is tenth in a series of 14 reports giving measurements of stages and flow made on U.S. waterways during the water year ending Sept. 30, '48. This statistical report, prepared in cooperation with California, Idaho, Nevada, Oregon, Utah and Wyoming and other agencies, uses tables to il-

(*Continued on page 62*)

(*Continued from page 60*)

lustrate the daily and monthly studies. —*P.H.E.A.*

Surface Water Supply of the United States 1947. Part 13. Snake River Basin. Geological Survey Water-Supply Paper 1093 ('50). This volume was prepared in cooperation with Idaho, Oregon, Utah, Washington and Wyoming and other agencies. One of a series of 14 reports presenting results of measurements of stage and flow made on streams, lakes and reservoirs in the U.S. during the water year ending Sept. 30, '47, the work was begun in 1888 in connection with special studies relating to irrig. Measurements of the flow of streams and of the stage and contents of lakes and reservoirs have been made at about 11,100 gaging stations in the 48 states and also at many in the territories of Alaska and Hawaii. In July '47, 5,810 gaging stations, including those in Hawaii, were being maintained by the Geological Survey and cooperating organizations. Miscellaneous dischg. measurements were made during the water year at many other points. Many states and private organizations have cooperated in the work, by furnishing data or by assisting in collecting data. —*P.H.E.A.*

Hydrologic Data on the French Broad River Basin 1857–1945. George R. Ross & W. H. Riley. N.C. Dept. of Conservation and Development, Div. of Water Resources and Eng. ('50). Prepared in cooperation with U.S.G.S. and U.S. Weather Bureau. Purpose of this publication is not to supply all the hydrologic information collected in the French Broad R. Basin, but to make available under one cover the information that can be readily used. Records at several weather stations as well as at several stream flow stations omitted as they would make the publication unnecessarily bulky and might be misleading to those that are not working with such data constantly. Full information on these stations can be obtained from the Div. of Water Resources and Eng. of the Dept. of Conservation and Development, Raleigh, N.C., and its cooperating agency, the U.S.G.S., Raleigh, N.C. Complete climatological data can be obtained from the U.S. Weather Bureau, Raleigh, N.C.—*P.H.E.A.*

Public Water Supplies in Southern Texas. W. L. Broadhurst, R. W. Sundstrom, & J. H. Rowley. Water Resources Div. and Texas State Board of Water Engrs. ('50). This report gives a summarized description of the public water supplies in 42 counties of southern Texas, extending from the Rio Grande northward to the northern boundaries of Kenney, Uvalde, Bandera, Kendall and Hays Counties and eastward to the eastern boundaries of Caldwell, Gonzales, Dewitt, Victoria and Calhoun Counties. It gives the following available data for each of the 114 communities: population of the community; name of the official from whom the information was obtained; ownership of water works, whether private or municipal; source of supply, whether ground or surface water; the amt. of water consumed; the facilities for storage; the number of customers served; the character of the chem. and san. treatment, if any; and chem. anals. of the water. Where ground water is used, the following information also is given: records of wells, including drillers' logs; character of the pumping equipment; yield of the wells and records of water levels, where available. The communities served by these public supplies had a population of 668,000 in 1940. Ground water is used by 79 of these communities and surface water by 31. The total amt. of water consumed

(*Continued on page 64*)

(*Continued from page 62*)

avgs. about 95 mgd., of which about 55 obtained from ground water and about 40 from surface water. The extreme northern part of the region lies on the Edwards Plateau, and the remainder lies within the Gulf Coastal Plain. The rocks that crop out in the region are practically all sedimentary and consist chiefly of limestone, shale, clay, sandstone, sand and gravel. They range in geologic age from Lower Cretaceous to Quaternary. The general geologic structure of the region is comparatively simple. The most prominent features are the regional gulfward dip of the formations at an angle greater than the slope of the land surface, which is a significant factor governing the occurrence of artesian water, and faulting along the Balcones fault zone which controls the occurrence and movement of ground water in the Edwards and associated limestones. Among the most important aquifers are the Edwards limestone of Lower Cretaceous age; the Carrizo sand, sands of the Mount Selman formation, the Oakville sandstone, and the Goliad sand Tertiary age; and the Lissie formation and sands of the Beaumont clay of Quaternary age. Each of these units has outcrop areas from which the beds dip beneath younger formations to increasingly greater depths. For convenience in summarizing the sources of municipal water supplies, the region has been divided into four areas, as shown on map. In area *A*, Bandera obtains its water from sands in the Trinity group; Divine in southeastern Medina County obtains water from sands in the Wilcox group or the Carrizo sand; and Boerne in southern

(*Continued on page 66*)

(Continued from page 64)

Kendall County obtains its supply from recent alluvium. The remainder of the municipalities in the area obtain water from the Edwards limestone, which has the greatest perennial yield of any aquifer in Texas. In area *B*, the Carrizo sand is the important aquifer in most of the area, although in the northeastern part several towns that are above the outcrop of the Carrizo sand obtain water from sands in the Wilcox group. In area *C*, all of the cities and towns use surface water with the exception of Falls City, Gonzales, and Three Rivers. In area *D*, which is adjacent to the Gulf coast, the principal sources of ground water are the Catahoula tuff, the Oakville sandstone, sands of the Lagarto clay, the Goliad sand, the Lissie formation, and sands of the Beaumont clay. Most of the public supplies obtained from surface water in southern Texas are filtered and frequently are given further treatment that alters the chem. character of the water. All except two of the supplies from the Rio Grande are given some chem. treatment and about two-thirds of them are filtered. Of the 182 anals. given in this report, 138 are from wells or springs. In general, the supplies from wells conform to the accepted standards of water qual. In dissolved solids about one-fourth of the waters have less than 500 ppm.; about three-eighths have between 500 and 1000 ppm.; and the remainder have more than 1000 ppm. Less than half of the supplies have chlorides of more than 250 ppm., and few have sulfates of more than 250 ppm. About one-third of the waters is in the soft to moderately soft range of hardness; another third is in the moderately hard to hard range and remainder is in the very hard range. The chem. compn. of the surface water varies through a rather wide range. At Rio Grande City, samples collected from the Rio Grande between 1935 and 1942 show dissolved solids ranging from 225 to 1760 ppm. million. At Three Rivers, samples collected from the Nueces River from 1941 to 1945 show dissolved solids ranging from 195 to 1068 ppm. At Spring Branch on the Guadalupe R., samples collected in 1942 show dissolved solids ranging from 150 to 540 ppm.; samples collected at Goliad from the San Antonio R. in 1942 show dissolved solids ranging from 110 to 750 ppm.—*P.H.E.A.*

GROUND WATER SUPPLIES

Geology and Ground-Water Resources of St. Croix, Virgin Islands. D. J. Cederstrom. U.S.G.S. Wtr.-Supply Paper 1067 ('50). The geology and ground-water resources of St. Croix, V.I., were surveyed by the U.S. Geological Survey as part of a program of test drilling for addl. water supplies. Water for human consumption obtained by collecting rain water, but almost all water for other purposes is obtained from wells, usually less than 100′ deep. The qual. of the water varies greatly, but in general is hard and contains a moderate to high amount of dissolved salts, present as sodium and calcium bicarbonate and chloride and, in lesser amts., as sulfate. Existing ground water supplies are used as water for maceration of sugar cane and for dilg. molasses in the manufacture of rum, but are too aggressive for use, without treatment, as boiler feed water. Recommendations for the development of water supplies on the island are made. Many ground waters would be suitable for domestic supply if they were protected from poln.—*W.P.A.*

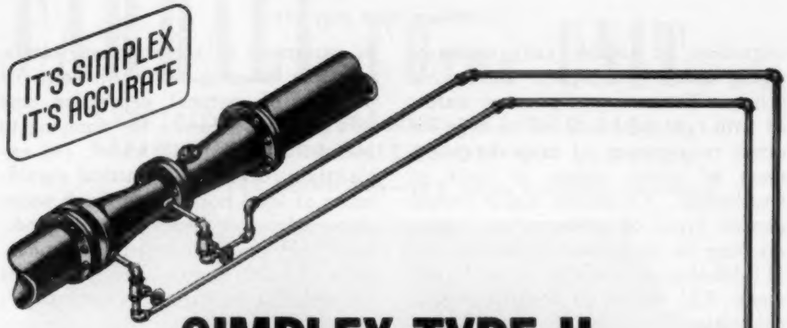
Genetic Types of Subterranean Waters and Their Utilization. I. I. Chebotarev. Wtr. and Wtr. Eng.

(Continued on page 68)

(*Continued from page 66*)

(Br.), 54:146 (Oct. '50). Laws of cycloidal migration of chem. elements in earth's crust enable est. of role of each of radicals in detn. of natural properties of subterranean waters. Chemical compn. of river waters, for example, not comparable to compn. of igneous rocks. At present relation of quantities of chloride, sulfate, alkalies and alkaline earths more important. Chlorides and sulfates are removed from rocks in first phase of weathering, while alkalies and alkaline earths combine with more stable components, forming such compds. as silicates. Second phase is characterized by loss of Ca, Na, Mg and K. Third phase corresponds to those conditions when major part of cations have been taken out and silica and aluminosilicates are broken down. Last phase is characterized by prevalence of iron oxide and alumina which have also undergone some change. Because there is appropriate type of sediment corresponding to each phase, whole of area from highlands to sea can be divided into following chief types: [1] residual products upon bed rock, [2] loamy and clayey drift, which may be considered as belonging to third and partly to second phase, [3] calcareous accumulation, which corresponds to first part of second phase, and [4] chloride-sulfate accumulation taking place in first phase. Two chief factors needing attention are: [1] ratio of carbonate to chloride; it decreases with increase of total salinity of subterranean water and with increase of chloride in particular; [2] percentage of sodium in relation to sum of Ca, Mg and Na increases with rise of salinity in water. Process of cycloidal

(*Continued on page 70*)


IT'S SIMPLEX
IT'S ACCURATE

(*Continued from page 68*)

migration of soluble salts embraces whole zone of lithosphere and hydrosphere. Formation of pressure waters of fifth type (chloride, saline type) is direct consequence of natural replacement of above phases in cycle of weathering. Variations within certain genetic types of subterranean waters are due to such local influences as: [1] lithological change in local sediments, [2] degree of hydrogeological connection between separate complexes of sediments, [3] particular conditions of dynamics of subterranean waters, [4] continuity of movement of waters. Successful utilization of subterranean waters requires study of number of problems, among which are: [1] salinity is bound up with circulation and drainage of subterranean waters; therefore, both static and dynamic conditions of saline waters must be studied; [2] water permeability and retaining properties of different types of sediments and aquifers, and velocity of movement of subterranean waters, must be investigated; [3] soln. of problem of optimal depression and safe radii of influence for pumping to prevent access of salt water; [4] explanation of role and practical significance of local horizons of fresh water above salt water under different conditions; [5] gradients of effective movement of subterranean water and limits of formation of stagnant (salt) water; and [6] hydraulic and hydrochemical interrelation between subterranean waters and sea water in coastal areas. Regional classification of waters should be based on: [1] systematization and generalization of existing information concerning subterranean waters; [2] classification of regional genetic types of waters; and [3] detn. of qualitative characteristics of waters for different practical purposes. Only study of dynamics of subterranean waters within basin, explanation of regions of active and delayed water exchange, and relation between separate provinces of basin can be considered as basis for correct judgment in quant. estn. of subterranean waters in artesian basin.—*H. E. Babbitt.*

Groundwater Resources in Champaign County. H. F. SMITH. Illinois State Water Survey Div., Dept. of Registration and Education, Report of Investigation No. 6 (1950). This investigation is part of a state-wide investigation of ground water resources being conducted by the State Water Survey Div. Records of more than 1400 wells have been tabulated. These wells penetrate one or more of 3 separate and distinct aquifers within the glacial drift. The 3 aquifers penetrated by wells in this area have unrelated hydrostatic heads. The avg. daily pumpage from the middle deposits, the major producing aquifer considered in this report, was 7.917 mil.gal. It was estd. that a total of 67,812 mil.gal of water has been

(*Continued on page 72*)

(*Continued from page 70*)

pumped from this aquifer. Water level pressure contour maps of the upper and middle water-bearing deposits show no similarity. Sufficient data not available to permit the constr. of a pressure contour map of the lower deposits. Values of the coefficients of transmissibility and storage have been detd. Values of the coefficient of transmissibility ranged from 10,000 to 400,000 and avgd. about 40,000. Values of the coefficient of storage ranged from 0.00024 for short periods to 0.0065 for a 46-yr. period, the longest for which records are available. Using a coefficient of storage of 0.0065 it was detd. that the amt. of water removed from storage since pumping began was about 3,187 mil.-gal. or about 5% of the total amount of ground water withdrawn. The amt. of inflow into the heavily pumped area at Champaign-Urbana is about equal to the 1948 rate of withdrawal, indicating little if any recharge within the 630 contour of the cone of depression. The steep hydraulic gradient and low water levels near the area of heavy withdrawal, together with contd. water level recession, suggest that the middle deposits at Champaign-Urbana have been developed to their max. transmission rate and that some lessening of the rate of withdrawal would be necessary to maint. constant operating water levels.—*Ed.*

Geology and Ground-Water Resources of Rice County, Kan. O. S. FENT. Univ. of Kansas Pubs., State Geological Survey of Kansas, Bul. 85 ('50).—The geography, geology, and ground-water resources of Rice County, central Kansas, described. With an area of about 721 sq.mi. and pop. in 1945 of 14,608 this county, in the Plains Border section of the Great Plains province, comprises dissected

(*Continued on page 74*)

(*Continued from page 72*)

uplands and filled valleys that present low topographic relief. Drained largely by Arkansas R. and tributaries, the avg. annual pttn. is about 26″ and the annual temp. about 56°F. Farming is principal occupation; wheat the major crop. In dry years small-scale irrig. practiced on a few farms. Petroleum and salt important mineral products. All exposed rocks in Rice County of sedimentary origin, ranging in age from Permian to Quaternary. A map shows surface geology and cross sections show distr. of unconsolidated material. Pleistocene deposits of Nebraskan, Kansan, and Wisconsinan Ages reach a thickness of more than 200′ and are composed mostly of unconsolidated material. Four major cycles of erosion and deposition recorded in Pleistocene rocks. The most important aquifers in the area are sand and gravel of the Pleistocene Series, the sandstones of the Dakota formation and of the Kiowa shale of the Cretaceous System. Descriptions of the ground-water conditions are given by formations and areas. All public and indus. water supplies and most domestic, stock and irrig. supplies are obtained from wells. The water is moderately hard to hard over most of the area. Water with a high chloride content is found in some of the Permian rocks, in deep Pleistocene channels, and in shallow deposits near points of disposal of highly mineralized indus. wastes. Hydrologic and geologic data, the basis of this report, include records of 266 water wells, 64 test holes, chem. anals. of 43 samples of water, the detn. of the chloride content of 89 samples of water, and periodic measurements of the water level in 22 observation wells.—*P.H.E.A.*

Scientific Approach to Underground Water Problems—II. T. A. Barnes. Commonwealth Engr., 37:460 (June 1, '50). The resources of underground water in Australia, selection of bore sites, estn. of bore output, and use of saline water discussed. A map of Australia shows main artesian basins, marginal high level basins and groups of mound springs. An artesian basin is the whole area within which pressure water exists, and from which artesian and subartesian waters can be obtained. To develop sufficient pressure to cause a notable rise of water in a borehole several conditions listed: [1] adequate rainfall to supply water to the aquifer, [2] aquifer both porous (able to absorb water) and permeable (able to transmit water), [3] less porous beds both above and below the aquifer, in order to confine water within the more porous bed, [4] intake sufficiently high above the level of the bore site to compensate for pressure loss due to friction, leakage, [5] no easy escape for water afforded at a lower level than the top of the bore. Author describes scientific selection of bore sites; quant., supply or output from bores; qual. of water; tests for qual. of ground water; suitability of underground water for agricultural purposes; and water for stock.—*P.H.E.A.*

Geophysical Interpretation of Underground Water Supplies; a Geological Analysis of Observed Resistivity Data. G. L. Paver. J. Inst. Wtr. Engrs., 4:237 ('50). The elec. resistivity obtained with various instruments in different sections of the earth and in different geol. strata and different hydrological conditions gives a scientific approach to the problem of underground water supply. Qual. of water: resistivities arising from water salinities above 1000 ppm. are all low and would approximately correspond to the limits set for potability for civil uses.—*C.A.*

Wells and Water Levels in Principal Ground-Water Basins in Santa Barbara County, California. G. A.

(*Continued on page 76*)

(Continued from page 74)

LaRoque Jr. Geological Survey Water-Supply Paper 1068 ('50). This report, prepared in cooperation with the County of Santa Barbara, Calif., presents in tabular form factual data on water wells and water levels in observation wells in 7 agricultural districts of Santa Barbara County. Part I contains data on the Carpinteria Goleta and lower and middle Santa Ynex Valleys in the southern part of the county; Part II contains the data on the San Antonio, Santa Maria and Cuyama Valleys in the northern part of the county. The data presented include altitude, depth, diameter, character and thickness of water-yielding material penetrated, depth to water, type of pump and use; and, for certain wells in which periodic water-level measurements have been made, the available measurements made prior to and during 1941. The location of each observation well is described; and the agency or company making each measurement indicated. The locations of all wells for which data are tabulated are shown on a map of each area.—*P.H.E.A.*

Water Levels and Artesian Pressure in Observation Wells in the United States in 1946. C. G. Paulsen. Geological Survey Water-Supply Paper 1072 ('50). This report was prepared by the Geological Survey in cooperation with the States of Alabama, Florida, Georgia, Kentucky, Maryland, Mississippi, North Carolina, Tennessee, Virginia and West Virginia and other agencies. The regular publication of records of water level and artesian pressure in the U.S. was begun by the Geological Survey in 1935 and has continued yearly since. This series of water-supply papers is in a sense an inventory, year by year, of the ground water supplies of such parts of the country as have been covered. The present volume covers the southeastern states and gives records of water level and artesian pressure in about 850 observation wells of the Geological Survey and cooperating agencies. Of these wells, 123 are equipped with automatic water-stage recorders. The report also includes about 17,000 individual detns. of water level and artesian pressure.—*P.H.E.A.*

Methane in Ground Water. C. H. Pope. Vattenhygien (Sweden), **3**:57 ('50). Examples of 6 well waters in Denmark are given contg. from 0 to over 60 ppm. CH_4. The occurrence of CH_4 is related to geological formations. Zeolithic minerals in soil and ion exchange in water are required because the formation of CH_4 takes place only in alk. water where the zeolithic material at pH values > 7.6 may supply the H^+ necessary for the production of CH_4. The underground formation of CH_4 through the growth and action of anaerobic, autotrophic bacteria is explained. Injurious effects of CH_4 on filters are described, and a method of removal of the gas by evacuation and neutralization is given. The conditions for the maint. of the correct redox potential are mentioned.—*Willem Rudolfs.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

Essentials in Corrosion Prevention for Water Works. E. B. Rodie, Pub. Wks., **80**:4:33 ('49).

Sanitary Engineering in the Occupied Zone of Germany. A. F. Meyer, J.N.E.W.W.A., **63**:277 ('49).

Diatomite Filters Turn Out Safe, Clean Water. Edwin S. Pegg. Eng. News-Record, **144**:20:35 ('50).

A Developer Comments on the Design of Contact Aeration Plants. Llewellyn B. Griffith. Eng. News-Record, **144**:11:38 ('50).

(Continued from page 16)

Once bit, quince shy is the story of meter reader Hinton Miller Jr. of Jacksonville, Fla., who bore up under the first, second and third toothings of canine meter minders, but turned in his resignation at fourth bite. Reason given was the "mental hazard" involved, but, knowing dogs as we do, we suspect that "trouser shortage" may have been at least a contributory cause.

"Rx for Meter Readers," a five-page anti-dog-bite policy, is available from A.W.W.A. headquarters at 5 cents per copy.—ADVT.

Donald V. Hackett has been appointed water works sales representative for Dresser Mfg. Div. in Pennsylvania and western New York.

The Pittsburgh Valve and Fittings Div. of Pitcairn Corp., located at Barberton, Ohio, has been acquired by Rockwell Mfg. Co., and its facilities will be used to expand Rockwell production.

Everett R. Partridge and R. R. Donaldson have been elected to the Board of Directors of Hagan Corp. and its subsidiaries, Calgon, Inc., and Hall Labs., Inc.

(Continued on page 82)

(Continued from page 80)

Water must have been what Mayor Impellitteri was thinking of the other day when he called New York "the cleanest city in the world." At least he watered down his statement just a little by adding "for its size." We might also point out that Mayor Impellitteri and his new water commissioner have also given New Yorkers the best public water supply in New York City for the moment, to the best of our knowledge—all things considered.

A new Norlantic meter, designed to meet A.W.W.A. specifications and special Canadian needs, has been introduced in that country by George Kent, Ltd., British instrumentation firm of Luton, Bedfordshire.

Changes in the Dearborn Chemical Co. organization recently effected include the appointment of C. S. White as head of the Water Treatment Dept., replacing S. H. Opdyke, retired, and Howard E. Johnston as manager of No-Ox-Id sales, succeeding C. A. Remsen, who passed away in January. Also retired were C. I. Loudenback and M. M. Kutzer, after 32 years of service each; and B. E. Conley, after 26 years with the organization.


SINKING TOO MUCH MONEY IN YOUR
WATER SOFTENING?
Deionize with
AMBERLITE IR-120
For These 3 Savings
1. Low Installation Cost. High exchange capacity means low equipment cost plus the ability to handle overloads easily. Even at peak flow rates of 25 gal./cu. ft./min., capacity is above 30,000 grains per cubic foot.
2. Low Operating Cost. AMBERLITE IR-120 thrives on a salt starvation diet—permits 50% reduction in regenerant requirements without affecting quality of softened water.
3. Low Maintenance Cost. The extreme stability of AMBERLITE IR-120 means years of trouble-free service without attrition losses. AMBERLITE IR-120 is unaffected by low-silica waters, which can dissolve zeolites. It can be operated safely over the entire pH range, and at elevated temperatures. It is unaffected by strong oxidizing and reducing conditions—chlorinated water causes no measurable deterioration.
ASK YOUR CONSULTING ENGINEER or water-treating equipment supplier about AMBERLITE IR-120—as the exchanger in a new softening installation, or as a replacement for siliceous exchanger. Meanwhile, write Dept. WW1-3 for full technical data.
CHEMICALS FOR INDUSTRY
ROHM & HAAS COMPANY
THE RESINOUS PRODUCTS DIVISION
Washington Square Philadelphia 5, Pa.
Representatives in principal foreign countries
AMBERLITE is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.

Service Lines

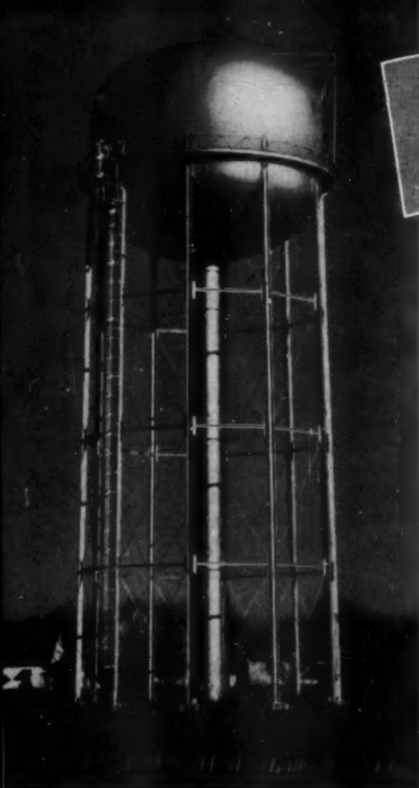
A 16-page booklet offered by Standard Pipeprotection, 3000 S. Brentwood Blvd., St. Louis 17, Mo., contains a picture-story of the processing of pipe at the new coating and wrapping plant. Details of the shipping and storing "in-transit" arrangements possible are given and suggested specifications for cleaning, wrapping and coating pipe are provided for the users' convenience.

Laboratory testing and analysis equipment available from General Electric Co. are described in a circular distributed by the company's Apparatus Dept. at Schenectady, N.Y. Among the items of equipment listed are a recording turbidimeter, a photometer, a spectrophotometer and, for research use, an ultrasonic generator.

A corrosion-resistance computer which indicates the proper metal or alloy to use for a wide variety of corrosive conditions is offered by H. M. Harper Co., 8200 Lehigh Ave., Morton Grove, Ill. The pocket-size slide type computer rates the value of thirteen metals for each application, thus permitting substitutions when particular alloys are scarce or unobtainable.

Diatomaceous earth filters made by Sparkler Mfg. Co., Mundelein, Ill., are described in a bulletin which has just been published. The Model SC filters, as they are called, are said to incorporate a self-cleaning feature which requires less than 7 minutes for cleaning.

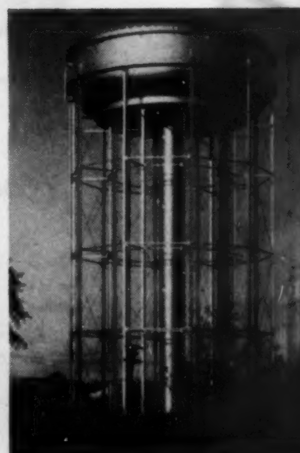
(*Continued on page 86*)



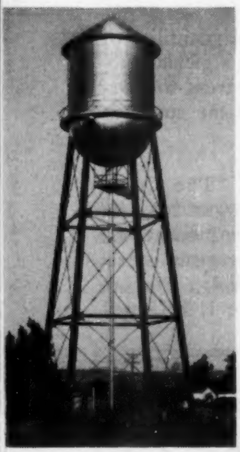
EVERY TYPE AND SIZE—
FOR EVERY NEED!

Elevated Steel Tanks

by PITTSBURGH • DES MOINES



Write today for our complete Elevated Steel Tank Brochure



For all municipal water storage requirements, Pittsburgh-Des Moines Elevated Steel Tanks are supplied in a wide range of designs, and in capacities up to 2,500,000 gallons. • Uniform pressures around the clock, supply during interruptions in pumping, lower pumping costs are but a few of the many reasons for this low-cost investment.

May we discuss the facts with you?

PITTSBURGH · DES MOINES STEEL CO.

Plants at PITTSBURGH, DES MOINES and SANTA CLARA

Sales Offices at:

PITTSBURGH (25), . . . 3424 Neville Island
NEW YORK (7), . Room 921, 270 Broadway
CHICAGO (3), 1228 First National Bank Bldg.
DES MOINES (8), ... 925 Tuttle Street
DALLAS (1), . . . 1229 Praetorian Building
SEATTLE . . . . 932 Lane Street
SANTA CLARA, CAL. . . 631 Alviso Road

(Continued from page 84)

A new, low-capacity hypochlorinator has been introduced by Wallace & Tiernan Co., Newark 1, N.J., and is described in a folder available from the company. Known as the Chlorinet, the unit is electrically operated and has been designed for ease of operation and dependability.

Use of cone-shaped barriers to guide and divert traffic during construction is explained in literature offered by Interstate Rubber Products Corp., 1638 W. Jefferson St., Los Angeles 7, Calif. Data on the cost and upkeep of the "Trafficones" are included.

Twin bellows design for liquid level control is featured in a four-page circular, Autocon Tanktrol Bul. 1100. Copies may be obtained from Automatic Control Co., St. Paul 4, Minn.

Control of slime in cooling waters by use of a new product, Santophen 45, a technical grade of sodium trichlorophenate, is the subject of a technical bulletin, No. 0–76, issued by Monsanto Chemical Co. Copies of the bulletin and experimental quantities of the new bactericidal and algicidal substance may be obtained from the Organic Chemical Div. of the company at St. Louis 4, Mo.

The March issue of "The Courier," external house organ of the Builders Iron Foundry organizations, carries an article on emergency sterilization of water supplies. Proportioneers, Inc., Providence 1, R.I., will send a copy if asked.

Removal of silica is the theme of a folder offered by the Resinous Products Div., Rohm & Haas Co., Washington Square, Philadelphia 5, Pa. "Zero Hardness by Amberlite Deionization" is the title to request.

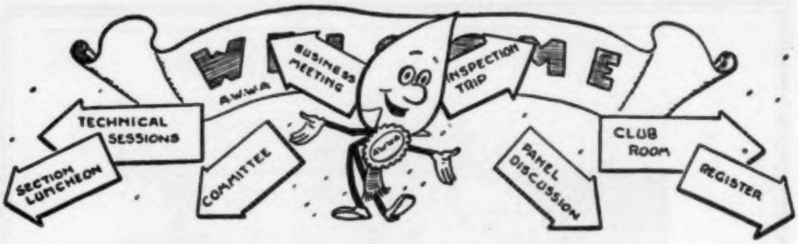
(Continued on page 88)

(Continued from page 86)

Pressure tapping of prestressed concrete pipe (steel cylinder type) is outlined and illustrated in a folder offered by Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio. The procedures for making both small- and large-diameter connections are described.

Welding fittings and forged steel flanges for steel pipe are the subject of a dimensional data card offered by Taylor Forge & Pipe Works, Box 485, Chicago 90, Ill. The 8½ by 11 in. card has been varnished on both sides for durability under constant reference. Fittings are listed for pipe sizes from ½ to 30 in., and flanges, for sizes up to 24 in.

Steel tubing for pressure and mechanical uses is the subject of a four-page folder available from Babcock & Wilcox Tube Co., Beaver Falls, Pa.



Section Meeting Reports

New York Section: The annual midwinter luncheon meeting of the New York Section was held in honor of visiting directors of the national organization at the Park-Sheraton Hotel, New York City, on Tuesday, Jan. 16, 1951. All of the directors were invited to be the guests of the section.

The two main topics, of vital interest at this time, were the "Controlled Materials Plan" and "Civil Defense." Robert L. Niles, of the National Production Authority of the U.S. Dept. of Commerce, outlined in detail the organizational plans to date on former subject. An A.W.W.A. committee, of which N. T. Veatch is chairman, presented in Washington an estimate of the raw materials needed in the essential water supply industry to the NPA.

Thomas F. Hurley, research analyst with the State Civil Defense Commission, outlined the general plans for New York State's civil defense, and was followed by a discussion by Earl Devendorf, state director of civil defense in water works. A committee of the New York Section was delegated by him to cooperate and supply information on inventories and manpower.

R. K. Blanchard
Secretary-Treasurer

Indiana Section: Zero weather following a sleet storm had little effect on the attendance at the 43rd annual meeting of the Indiana Section held in Indianapolis Feb. 7–9, 1951. Actual registration was 299; total attendance, including the ladies, was over 335.

The only empty chairs were in the front row as O. J. Muegge, state sanitary engineer of the Wisconsin Board of Health, delivered a joint paper at the first session on the "Pros and Cons of Fluoridation" for partial control of dental caries. He pointed out that at an average estimated cost of $0.10 per capita per year an individual who lived to be 70 years old would pay only $7.00 for this protection—which is a good investment when con-

(*Continued on page 92*)

(*Continued from page 90*)

sidered in relation to a dentist's bill. George G. Fassnacht of the Indiana State Board of Health and L. J. Beckman of Wallace & Tiernan Co., Inc., Chicago, gave short discussions on, respectively, the attitude of the State Board of Health toward fluoridation in Indiana, and the equipment and materials used by communities which are now adding fluorides.

Louis R. Howson, of Alvord, Burdick and Howson, Chicago, presented his paper on "The Economics of Water Softening" (*see* p. 253, this issue) with figures and charts to substantiate his conclusion that eventually most public water supplies having a hardness of 125 ppm. or more will be softened. David P. Backmeyer, superintendent at Marion, and Thomas J. Burrin, superintendent at Lebanon, commented on the paper as it applied to the softening plants in their own communities.

After dinner Wednesday evening, Robert J. Kryter, of the Esterline-Angus Co., Inc., Indianapolis, manufacturers of electrical and electronic instruments, astounded his audience of 150 with details of atomic reaction. "One of our atomic factories," he said, "has a fenced factory site bigger than the state of Rhode Island." Illustrating potential atomic force, Mr. Kryter told his audience that the material in the 10¢ piece which he held, if completely destroyed through atomic reaction, would liberate enough power to lift the Empire State Building 52 miles. We cannot ask with Cain, "Am I my brother's keeper?", and live long with this potential force.

The topics on Thursday morning were chosen to cover a community of interests shared by the water utilities and industrial water users. Alfred O. Norris, manager of the Indianapolis Water Co., outlined "Problems Common to Public and Industrial Water Supplies," stressing the factors involved in the financial considerations. In his paper, "Planning Future Expansions to Meet Public and Industrial Requirements," Paul D. Cook, city manager of Painesville, Ohio, stressed that "in no sense, and at no time, is the process of planning static in the thinking of a progressive and an alert water works administrator." He then indicated sources of information and methods of analysis which should be helpful to the water works superintendent in making a continual critical analysis of the limitations of his system and the possible future demands that will be placed on it.

C. D. Adams, chemical engineer from Colgate Palmolive Peet and Co., New Albany, used case histories to illustrate "Quality Control of Industrial Water Supplies" which went beyond the basic controls normally exercised by public water supplies. Corrosion, slimes and scale formations are perennial headaches in industry. Herbert H. Young, chief engineer, and D. T. Sherow, chemist, of Stokely Foods, Inc., Indianapolis, analyzed industry's growing water problem as one of quality as well as quantity. Calcium salts, for instance, are highly detrimental in certain phases of packing sweet peas, but for other products, like canned tomatoes, calcium salts may be added to increase firmness. The authors contend that iron will do as

(*Continued on page 94*)

(*Continued from page 92*)

much damage to light colored products, such as white, cream-style corn or hominy, as it will to a white shirt in the laundry. In some products iron will produce off flavors. To prove their point they brought samples of peas and corn packed under different water conditions for the men to observe and taste.

In the afternoon session Clarence F. Hill, mayor of Rochester, talked about "The Mayor's Responsibility to His Water Works." Water is now a commodity with quality of prime importance. "Politics and water don't mix any more than politics and electricity," he said. "Let's keep the utilities that are municipally owned on a service basis." In exploring the subject, "Civilian Defense and Mutual Aid in Event of Atomic Bombings," Wendall R. LaDue, superintendent and chief engineer of the Akron, Ohio, Bureau of Water and Sewerage, pointed out that all of the present planning is based on the bomb that dropped at Hiroshima. While this may give some foundation material it does not qualify us to plan in minute details for future eventualities. He stressed the importance of applying "water works know-how" to situations which may develop from a bombing as soon as stock can be taken of conditions. For precatastrophe planning he suggested taking inventory of men, equipment, feeder mains, plants, materials and other critical items and carefully studying possible damage. Dispersal of both equipment and personnel will keep one bomb from robbing all facilities, and mutual aid among cities and communities was suggested as a much better tool than a government agency which would try to move in after a disaster.

Speaking on "A Water Works Man's Place in His Community," Leo Louis Jr., formerly head of the Water Supply Section of the Indiana State Board of Health, and now superintendent of the Water Dept. at Cedar Rapids, Iowa, pointed out the responsibilities and integrity demanded of the water works man by the A.W.W.A. Code of Ethics. He stressed the importance of water works people becoming a part of the constructive force in the community by contributing time, membership and money to the basic organizations which sponsor community progress.

The banquet Thursday evening featured two past presidents and W. V. Weir, the current president of the national Association, at the speakers' table. The Fuller Award was presented to Howard W. Niemeyer for his careful analysis and effective reporting of experience in distribution system operation, which has resulted in improved water works practice in this field. The Section's Bradley Award was given for the current year to the Northwestern Area on the basis of attendance at Fall District Meetings and new memberships.

Entertainment by the Northern Indiana Public Service Co. Male Chorus was followed by a social hour which featured dancing and vaudeville acts.

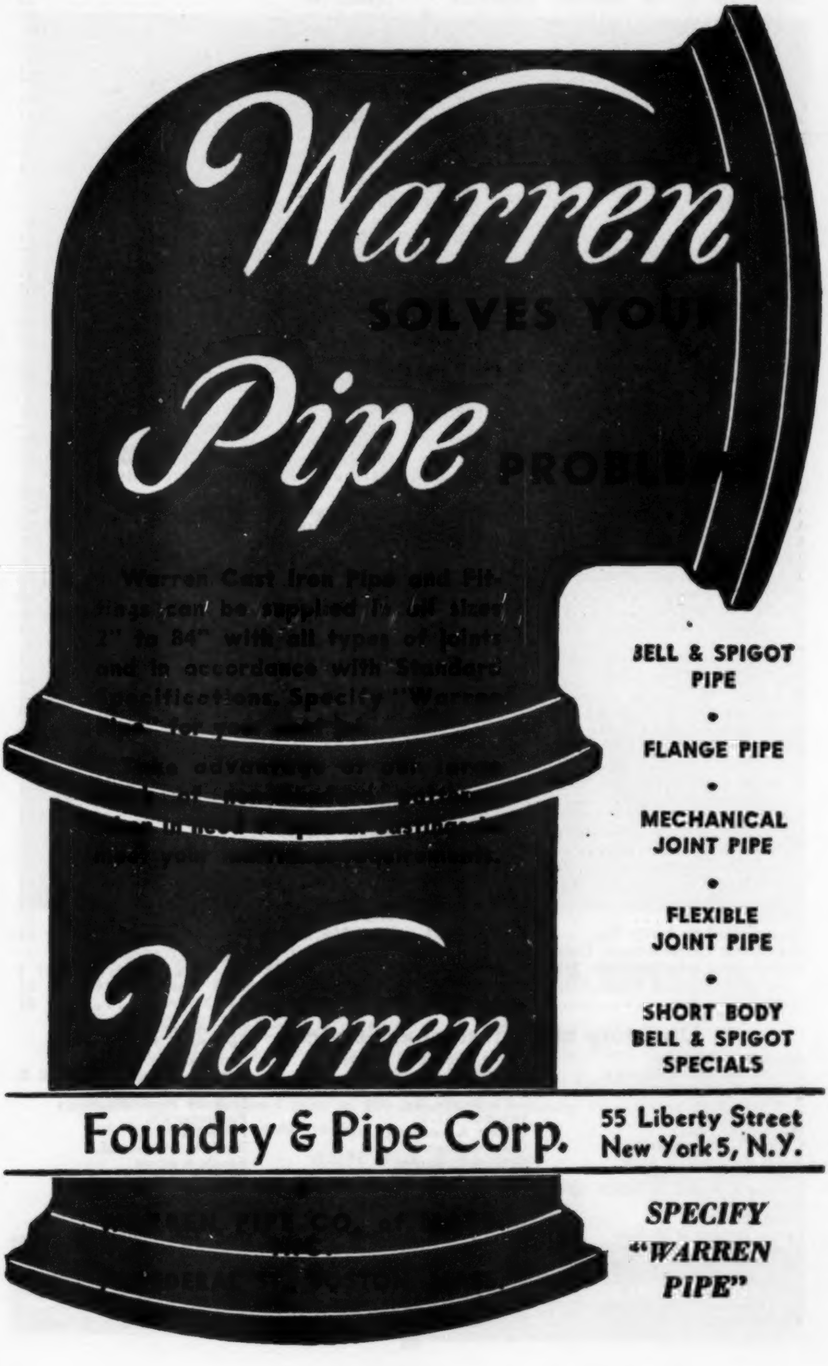
(*Continued on page 96*)

(Continued from page 94)

On Friday morning John Rian, District General Foreman of Gas and Water Operators, from Gary, presented a thorough discussion on "Use and Operational Control of Mechanical Equipment." He emphasized proper training of men to use mechanical equipment. "Criticism of the individual," he said, "causes him to defend his actions rather than to improve his practice. Training rather than criticism should be emphasized." In a discussion of this paper Howard Niemeyer stated that noncompetitive industry—such as a water utility—should check its efficiency occasionally. He indicated the need for mechanization and for replacement of obsolete machines with the most efficient type of equipment. In the Indianapolis Water Co. the wages for labor on pipe laying crews have increased 150 per cent between 1930 and 1949. Due to efficient mechanization during the same period, the amount of pipe laid per man per year increased from a little less than 1,000 to approximately 3,500 ft. while labor costs decreased from \$0.58½ to \$0.32 per foot. As further illustration of value of machines, he listed two dozen uses for compressed air in construction and maintenance work.

A. B. Daugherty, of East Gary, presided over the question period which closed the technical program. The unusual cold weather this winter has caused an epidemic of main breaks in some southern cities, characterized by a transverse fracture of the cast iron barrel and subsequent horizontal separation without vertical displacement. Most of the trouble seems to have appeared in bell and spigot pipe laid with sulfur jointing compound. The majority of the failures also occurred with the first sharp drop in water temperature in surface water supplies. The concensus seemed to be that the internal stress due to contraction added to existing transverse loads was enough to cause rupture. The question of who pays for fire hydrants damaged by automobiles nearly broke up the session when one superintendent reported that as chief of police he investigated all such accidents and collected damages from the driver of the car. In fact he had collected three times. on one hydrant this winter before he had a chance to repair it.

George G. Fassnacht
Secretary-Treasurer


Warren
Pipe
Warren Cast Iron Pipe and Fit-
tings can be supplied in all sizes
2" to 84" with all types of joints
and in accordance with Standard
BELL & SPIGOT PIPE
FLANGE PIPE
MECHANICAL JOINT PIPE
FLEXIBLE JOINT PIPE
SHORT BODY BELL & SPIGOT SPECIALS
Warren
Foundry & Pipe Corp.
55 Liberty Street
New York 5, N.Y.
SPECIFY "WARREN PIPE"

LIST OF ADVERTISERS

Directory of Professional Services—pp. 25-29

Index of Advertisers' Products

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1950 Membership Directory.

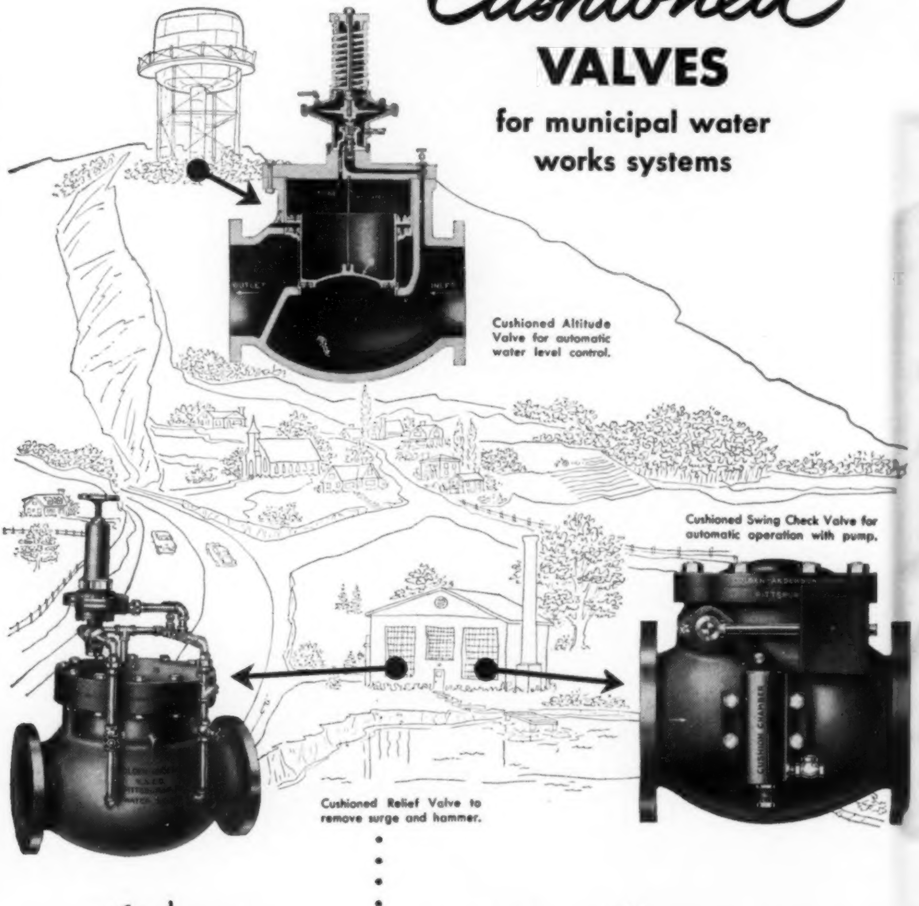

WE'LL SEE YOU IN
MIAMI..
AT THE
A. W. W. A. ANNUAL
CONFERENCE
THE ONE MEETING
YOU CAN'T AFFORD TO MISS!
This could be the most important conference ever held. The discussions in Miami will cover timely problems that are perplexing all water works operators. Should world conditions fail to improve this may be the last national meeting for many years. It deserves your attendance. We hope to see you there.
SEE OUR EXHIBIT
BOOTHS 90-91-92
We invite you to meet and greet old friends and new in our exhibit area. Our facilities are at your disposal. Feel free to use them.
ROCKWELL
ROCKWELL
MANUFACTURING COMPANY
PITTSBURGH 8, PENNSYLVANIA . Atlanta, Boston, Chicago, Columbus, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa

Prevent Hammer or Shock

Specify **Golden-Anderson**

"Cushioned" VALVES

for municipal water works systems



Cushioned Altitude Valve for automatic water level control.

Cushioned Swing Check Valve for automatic operation with pump.

Cushioned Relief Valve to remove surge and hammer.

Write → **for new engineering bulletins designed for you**

GOLDEN-ANDERSON *Valve* SPECIALTY COMPANY
2091 KEENAN BUILDING PITTSBURGH 22, PA.

LIFE AND PROPERTY PROTECTION
VALVES
FOR OVER 50 YEARS